Middle Rio Grande Fuels Reduction Study
2004 Annual Report
Prepared by USFS Rocky Mountain Research Station

Rocky Mountain Research Station

Address:

USDA Forest Service
Rocky Mountain Research Station
333 Broadway SE, Suite 115
Albuquerque, NM 87102-3497
Main Phone Line: 505-724-3660

Authors and Contacts:

Deborah M. Finch, Ph.D. Principal Investigator, Research Wildlife Biologist, dfinch@fs.fed.us

Roy Jemison, Ph.D., Research Hydrologist, Soils and Hydrology, rjemison@fs.fed.us

Alice Chung-MacCoubrey, Ph.D. Research Wildlife Biologist, Mammalian Biology and Herpetology, achungmaccoubrey@fs.fed.us

June Galloway, Wildlife Biologist, jgalloway@fs.fed.us

Heather Bateman, Biological Technician & UNM Graduate Student, Herpetology, hbateman@unm.edu

David Hawksworth, Biological Technician,Vegetation and Avian Biology, 2005 Annual Report Assembler, dlhawksworth@fs.fed.us

Cooperators:

David Merritt, Ph.D., Ecologist, Stream Systems Technology Center, Fort Collins, CO, dmmerritt@fs.fed.us

Brad Johnson, Ph.D. Ecologist, Colorado State University, bjohnson-jec@comcast.net

Georgeanne Moore, Ph.D. Texas A&M, gwmoore@tamu.edu

Kieth Owens, Ph.D., Texas A&M, m-owens@tamu.edu

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Introduction

Along the Middle Rio Grande, the increasing proliferation of exotic woody plants has altered the structure and composition of riparian vegetative communities, and greatly increased the frequency and severity of wildfire. Dead and downed wood and exotic Salt Cedar (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*) are fuels that lead to high fire risk in the Bosque. Salt Cedar plants possess many stems and have high rates of stem mortality, resulting in accumulations of dense, dry dead branches (Hart, 2002). When dense salt cedar stands burn, the fires are often intense and fast moving. Salt Cedar's high flammability places native bosque flora and fauna at increased risk of mortality by fire. Native tree species inhabiting the middle Rio Grande, such as the Rio Grande cottonwood (*Populus deltoides* ssp. *wislizeni*) and Goodding's Willow (*Salix gooddingii*) are not fire-adapted, cannot resist fire damage and do not respond with regenerative resilience to fires (Busch, 1995).

The Rocky Mountain Research Station's (RMRS) Middle Rio Grande Fuels Reduction Study is monitoring and evaluating the responses of groundwater, soils, vegetation, bird, bat, reptile, and amphibian populations to three fuels reduction treatments at 12 research sites. Sites extend from the southern portion of Albuquerque to the Bosque del Apache National Wildlife Refuge (USFWS) 20 miles south of Socorro. The fuels reduction study was initiated in 1999 under a Memorandum of Understanding among several partners, including Bosque del Apache National Wildlife Refuge, Middle Rio Grande Conservancy District (MRGCD), City of Albuquerque Open Space (COA), Bureau of Land Management (BLM), New Mexico Department of Environment (NMDE), and NRCS Plant Materials Center (Los Lunas, NM). Pretreatment data were collected from 2000-2002. Data were collected at all sites during the 2003-4 seasons at varying stages of treatment.

Project Status

With the exception of MI-2 (see Table 1 for site locations and treatments), all treatment sites were cut and follow-up treatments initiated prior to the start of the 2004 field season. MI-2 was treated over the winter of 2004-2005 and post-treatment monitoring will begin in the 2005 field season. Since treatments had not been completed prior to the 2004 field season, only a partial analysis of the results is possible.

Two research sites were partially burned by wildfires during the 2004 field season. A fire on June 11th burned the south end of NO-2 destroying about 3.9 acres of the site including one bird point count station. On June 18th, the Abeytas Fire burned approximately 6.1 acres at the north end of SO-1. Two bird counts stations and one herpetofaunal array were destroyed in this fire. The remainder of these sites did not suffer any noticeable permanent damage although many cottonwoods along the edges of the fires were singed and lost many leaves.

A decision was made to make no further changes in site boundaries or point count stations and to continue surveying birds at the same survey points in burned areas. We concluded it was valuable to continue monitoring in the same locations rather than add more variation by changing point count locations. The station data can be eliminated, if needed, during the data analysis period.

Technology Transfer

As part of the effort to disseminate knowledge gained by this study, various presentations, papers and talks were produced over the last year by RMRS personnel. Posters and presentations were presented at the Joint Fire Sciences Program Annual Meeting in Phoenix, AZ; the Monitoring, Science and Technology Symposium in Denver, CO; the National Fire Plan meetings in Albuquerque; the Forest Service grasslands biologists meeting in Socorro, NM and the Defenders of Wildlife Carnivore Symposium in Santa Fe, NM. Papers produced for publication include:

Chung-MacCoubrey, A. L. and H. L. Bateman. In press. Herpetological communities of the Middle Rio Grande bosque: what do we know, what should we know, and why? In: Aguirre-Bravo, Celedonio, et. al. eds. Monitoring Science and Technology Symposium: Unifying Knowledge for

Table 1. Site Treatment Plans and Locations

Block	Site	ID	Treatment	Land Manager	Size (ha)	Location
North	North-1	NO-1	Control	Albquerque,MRGCD,NMSP	16.07	1 mile south of Rio Bravo Ave. in Albuquerque - west side of river
North	North-2	NO-2	Revegetation with native vegetation	Albquerque,MRGCD,NMSP	18.33	2 miles south of Rio Bravo Ave. in Albuquerque - west side of river
North	North-3	NO-3	Mechanical removal and chipping	Albquerque,MRGCD,NMSP	17.03	5 miles south of Rio Bravo Ave. in Albuquerque - west side of river
North	North-4	NO-4	Controlled Burn	Albquerque,MRGCD,NMSP	23.43	1.5 miles south of Rio Bravo Ave. in Albuquerque - east side of river
Middle	Middle-1	MI-1	Mechanical removal and chipping	MRGCD	19.41	2.5 miles north of US Highway 6 in Los Lunas - east side of river
Middle	Middle-2	MI-2	Controlled Burn	MRGCD	29.17	1 mile south of US Highway 6 in Los Lunas - west side of river
Middle	Middle-3	MI-3	Revegetation with native vegetation	MRGCD	13.21	1 mile south of NM Highway 346 - west side of river
Middle	Middle-7	MI-7	Control	MRGCD	35	6 miles south of US Highway 6 in Los Lunas - west side of river
South	South-1	SO-1	Control	MRGCD	28.87	3 miles north of US Highway 60 - west side of river
South	South-2	SO-2	Revegetation with native vegetation	MRGCD	15.54	.5 mile north of Escondido Lake Road - east side of river
South	South-3	SO-3	Controlled Burn	Bosque Del Apache NWR	26.71	North end of Unit 7 at Bosque del Apache NWR
South	South-4	SO-4	Mechanical removal and chipping	Bosque Del Apache NWR	15.45	North end of Unit 27 at Bosque del Apache NWR

Sustainability in the Western Hemisphere; 2004 September 20-24; Denver, CO. Proceedings RMRS-P-000.

Finch, D.M., J. M. Galloway, and D. L. Hawksworth. 2004. Monitoring bird populations in relation to fuel loads and fuel treatments in riparian woodlands with tamarisk and Russian olive understories. In: Aguirre-Bravo, Celedonio, et al. Eds. Monitoring Science and Technology Symposium: Unifying Knowledge for Sustainability in the Western Hemisphere; Denver, CO. Proceedings RMRS-P-000. Ogden, UT: U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Cooperators

Two additional research projects were initiated during the 2004 field season. Dr. Georgianne Moore of Texas A & M University is the principal investigator on a project examining potential water savings from exotics removal. Dr. David Merritt of the US Forest Service is the lead investigator examining vegetative response to mechanical removals. For a summary of their preliminary results, see Appendices 4 & 5.

Hydrology and Soils Results

The removal of Salt cedar and other exotic woody species that have invaded the Middle Rio Grande bosque have the potential to reduce the amount of water lost via evapotranspiration. Groundwater observation wells with recording data loggers were installed at each study site to continuously monitor changes in groundwater levels before and after treatments to address this issue. Table 2 summarizes background information about groundwater wells. Groundwater levels are measured and recorded every 15 minutes with a pressure transducer. Plots of the depth to water at each site are presented in Appendix 1.

Table 2. Coordinates and characteristics about monitoring wells.

Site ID	UTM Coordinates – NAD 27 Array 1	Array 3	Start Date	Soil Texture at Surface and at 1 m	Depth to Water (mm) High and Low
North-1	3875068	3874845	6/2001	Silt clay loam	288.5
	346537	346283		Silt clay	337.4
North-2	3873314	3872628	6/2001	Loam	267.5
	345968	345880		Silt clay loam	305.0
North-3	3869581	3868958	6/2001	Silt loam	201.0
	346021	346224		Sand	241.8
North-4	3874337	3873724	6/2001	Fine sandy loam	288.5
	346383	346312		Very fine sandy loam	439.4
Middle-1	3857186	3856658	6/2001	Fine sandy loam	223.5
	343389	343375		Loamy sand	408.0
Middle-2	3850559	3850218	6/2001	Clay loam	387.0
	341919	341602		Sand	497.5
Middle-3	3822520	3822374	6/2001	Loam	239.5
	337088	336834		Loamy fine sand	396.7
Middle-7	3843111	3842411	10/2002		272.0
	340340	339659			380.0
South-1	3815047	3814435	6/2001	Very fine sandy loam	370.4
	334428	334590		Silt loam	467.6
South-2	3779004	3778254	6/2001	Silt clay loam	329.0
	326959	326868		Very fine sandy loam	428.4
South-3	3748267	3747842	6/2001	Sandy loam	361.9
	328549	328903		Fine sand	506.8
South-4	3742790	3742105	6/2001	Silt clay	233.3
	327847	327832		Silt clay loam	420.5

The primary source of groundwater in the bosque is water that percolates into the ground from the river and canals that pass through the bosque. Figure 1 illustrates river mean daily discharge measured at a USGS gage near the north study block.

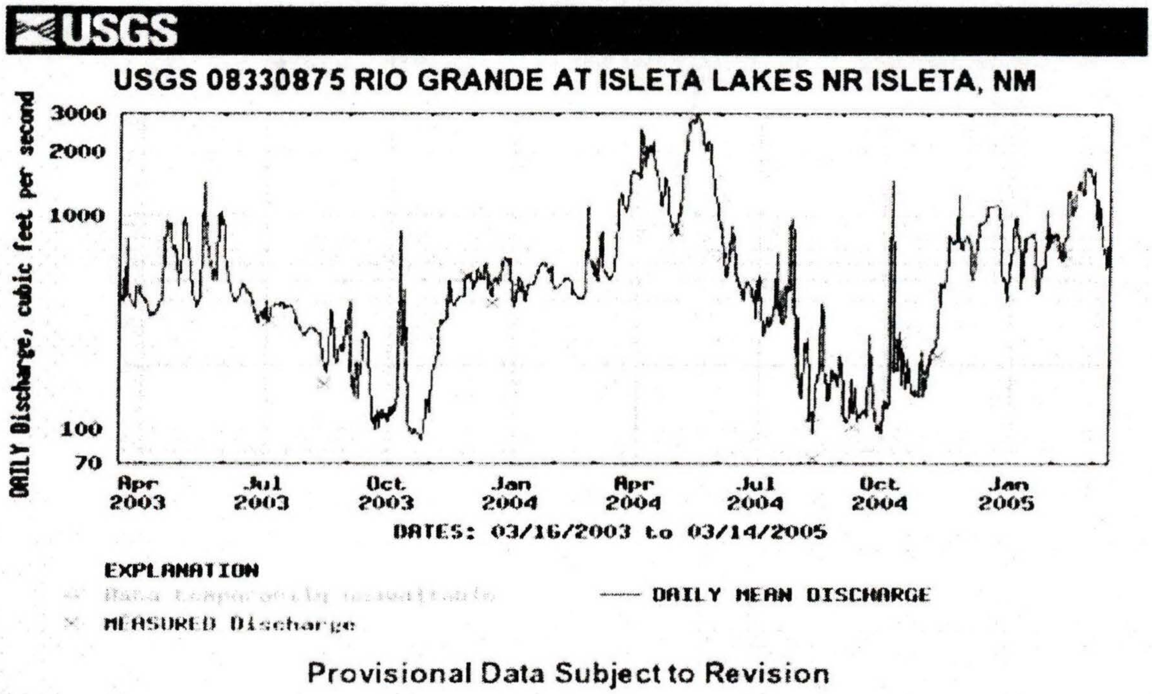


Figure 1. Rio Grande discharge at USGS gage 08330875 near the North study block and Isleta, NM (U.S. Geological Survey 2005).

Direct precipitation is an important water source for plants in the Rio Grande bosque. However in general, it is not a major contributor to the groundwater levels in the areas where it falls. Figures 2 and 3 summarize the precipitation recorded near the northern and southern limits of our study areas.

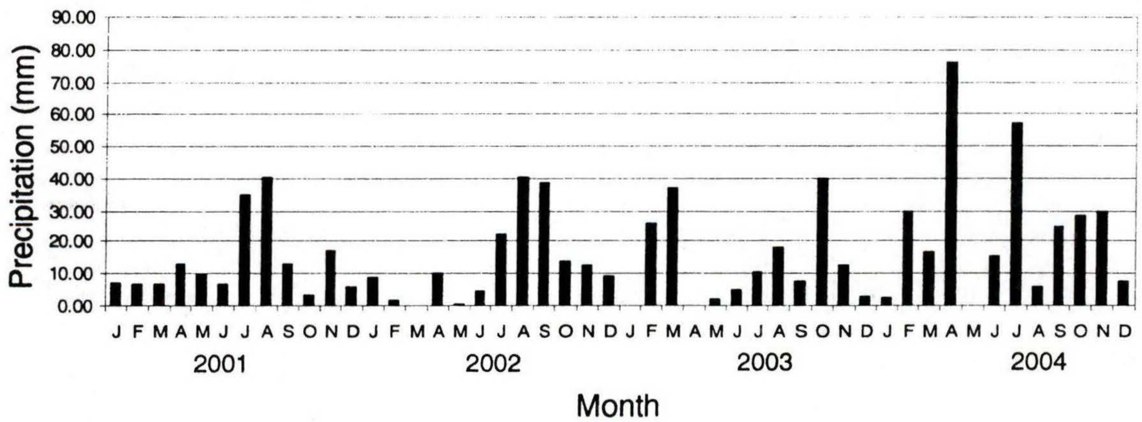


Figure 2. Precipitation at the Albuquerque International Airport (Western Regional Climate Center 2005).

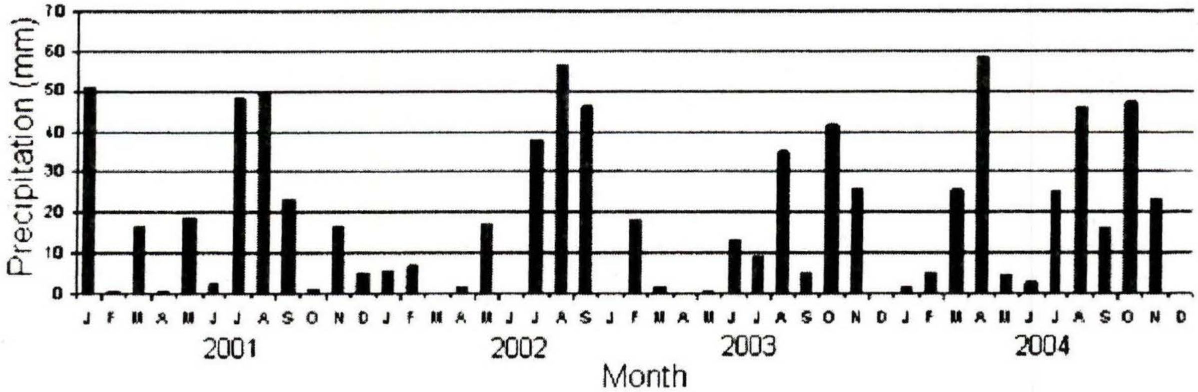


Figure 3. Precipitation recorded at Bosque del Apache (Western Regional Climate Center 2005).

Vegetation and Habitat Sampling Surveys

Descriptions of Methods

not cut

Prior to the start of fuels reduction treatments in the fall of 2002, one vegetation surveying point per herp array and two vegetation surveying points per bird count station were established. Points were set up either 25 meters from the center of the herp array equidistant between 2 herp fences or 25 meters from the bird count stations in opposite directions (either NW and SE or NE and SW). In rare cases, points were not located in opposite directions if doing so would have placed a sampling point outside the cottonwood gallery forest habitat. Vegetation and habitat sampling surveys were conducted at each sample point was prior to the start of treatments and again in 2004 with the exception of MI-2. MI-2 was the only treatment site not completed prior to start of the field season in 2004 and will be resampled in 2005 as cutting is now complete at this site. Each vegetation sampling point was resampled using the same techniques used previously with the exception of a few small improvements made to better characterize the habitat.

Variable Circular Plots

To get an estimate of basal area and tree densities, all woody plants detected from the center of the vegetation sampling point in any direction using a 2.5 basal area prism were identified to

species and their diameter at breast height (DBH) measured and recorded. In cases where a plant had more than one stem or trunk that was DBH high, only the largest trunk or stem was measured.

4-Meter Radius Vegetation Plots

All plants within 4 meters of vegetation point centers were identified to species and counted. In the case of very common grass or forb species, numbers were frequently estimated. In addition, all woody plants on the 4-meter diameter plots that were at least 4.5 feet tall (DBH) were identified to species and their DBH measured and recorded. In cases where woody plants had more than one stem or trunk that was DBH high, only the largest was counted.

1-Meter Radius Stem Density Plots

All woody stems emerging from the ground (except salt cedar) within one meter of the vegetation point center were counted and identified to species to get an estimate of stem densities on plots. Only salt cedar stems greater than 2 cm in diameter at ground level were counted on these censuses.

Ground Cover Transects

A 50-meter transect was set up at each vegetation sampling point to measure ground cover prior to the start of treatments in 2002 and each of these transects was sampled again in 2004. Ground cover at each meter along the transect was recorded in one of eight cover types (litter, woody debris, bare ground, grasses, forbs, shrubs, trees and miscellaneous other). The amount of each cover type was then used to estimate per cent ground cover for each type of cover. In 2004, one additional cover types was also recorded. Wood chips were added as a ground cover category to estimate the amount of ground left covered by chips from the treatment process.

The ground cover transect was also used to obtain a rough estimate of canopy cover. A densiometer reading was taken at each meter along the transect estimating whether the canopy was mostly open or mostly closed. This produced a per cent canopy closure cover estimate for each transect.

Dead and Downed Woody Debris Transects

1 50-M transect was set up at each vegetation sampling point to record dead and downed woody debris. These transects were located at the same places as the ground cover transects. On these transects, all dead woody debris in three class sizes (2-5; 5-20 and >20 cm in diameter) in four equal height categories up to two meters above the ground were counted. Each of these transects was sampled before and after treatments to measure the changes in the amount of dead woody debris from the treatments.

Fuels Transects

1 50-foot transect was established at each vegetation sampling point to measure fuel loads on the sites. Measurements were taken following the protocols established by the Fuels Management Program and analyzed using this program. Each transect was resampled in 2004 to examine changes.

Vegetation and Habitat Sampling Survey Results

Variable Plot surveys

The removal of exotic trees and shrubs from treated sites reduced the basal area of exotics and numbers of exotic trees to essentially zero on all sites. One uncut Siberian Elm on NO-4 was the only exotic plant recorded on any post-cutting variable plot surveys compared to an average of 0.4 exotic plants recorded per plot prior to cutting. As would be expected, numbers of native trees were virtually unchanged because no treatments were done to them apart from the removal of a few snags.

4-Meter Radius Plots

It was presumed that the removal of exotic shrubs would increase the ground cover of forbs and grasses as well as native shrubs. As might also be expected, increases in detected forbs and grasses are already evident whereas there has not yet been enough time to detect a noticeable

increase in native shrubs. Five of the eight treated sites showed increases in ground cover plants after the cuttings, though in some cases these changes are not significant (Table 3). It is probable that some of the increase was due to improved growing conditions in 2004 compared to 2000 and 2001, as rainfall was significantly above normal in the spring of 2004 for most of the Rio Grande Valley and higher than either 2000 or 2001 (National Weather Service records).

Considerably more species of plants were recorded in the post-treatment round of surveys. This was probably due in part to improved growing conditions and changes in observers in addition to the effects of the clearing treatments. A total of 53 species of grasses and sedges (11 exotic and 42 native) and 162 species of forbs (28 exotic and 134 native) have been recorded on the 4-M radius plot surveys (Appendix 2).

There was no noticeable change in the species composition of the most common ground cover plants before and after treatments (Table 3). Eight of the ten most commonly recorded species of forbs and grasses detected in post-treatment surveys were among the ten most common species recorded on pre-treatment surveys as well. One species, *Panicum obtusem*, may have increased as a result of treatments as it was not found on any pre-treatment surveys of the 11 sites surveyed again in 2004 (although it was very common on MI-2 on pre-treatment surveys and increased the greatest on a control plot). The other grass species that appeared to increase was *Sporobolus airoides*.

Only 3 of 8 treated sites and 1 of 3 control sites showed increases in native shrub cover after exotic removal (Table 4). No new shrub species were detected in post-treatment surveys except for newly planted shrubs at some of the revegetation sites. A very small portion of the decrease in native shrubs was due to plants accidentally removed by the cutting crews.

The removal of exotics produced substantial changes in the relative numbers of large trees and shrubs on the 4-meter plots (Figures 4 & 5). No exotic plants greater than 5 CM in DBH were recorded on any plot, leaving all treated plots with 100% native vegetation among larger shrubs and

Table 3. Changes in Ground Cover - Most Common Forbs and Grasses and Total Plants
(Mean Number of Plants per 4-M Radius Plot)

		ANCA		ACRE		COCA		DESO		MEOF		MUAS		PAOB		RATA		SOEL		SPsp		All Others		All Plants	
Site		**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
NO1	**Control - 2001**	1.32	5.74	13.16	32.67	0.00	0.00	0.05	0.23	0.05	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58	5.72	16.16	32.33
NO1	**Control - 2004**	0.00	0.00	15.79	37.46	0.05	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	2.29	0.00	0.00	2.89	11.46	19.26	37.69
NO2	**pre-treatment**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26	22.94	0.00	0.00	0.00	0.00	1.32	5.74	0.00	0.00	4.16	12.47	10.74	25.40
NO2	**post-treatment**	5.88	24.25	0.00	0.00	3.24	7.16	0.00	0.00	1.00	2.24	0.35	1.00	0.00	0.00	0.00	0.00	2.06	8.49	0.00	0.00	9.41	15.72	21.94	34.48
NO3	**pre-treatment**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47	6.06	1.47	6.06
NO3	**post-treatment**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.76	6.07	1.76	6.07
NO4	**pre-treatment**	0.00	0.00	2.63	11.47	0.05	0.23	9.21	25.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.95	12.54	0.05	0.23	12.37	23.22	28.26	50.49
NO4	**post-treatment**	0.00	0.00	0.26	1.15	1.84	4.48	0.68	2.31	0.05	0.23	0.00	0.00	0.00	0.00	2.63	11.47	5.37	15.73	1.16	3.56	25.68	61.00	37.68	80.11
MI1	**pre-treatment**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.89	7.87	0.00	0.00	0.00	0.00	5.32	22.93	0.05	0.23	0.00	0.00	43.95	55.46	52.21	60.14
MI1	**post-treatment**	0.00	0.00	1.74	7.57	0.11	0.46	0.00	0.00	0.68	2.31	8.00	23.61	0.05	0.23	4.05	9.71	0.05	0.23	1.42	5.73	32.32	51.68	48.42	62.66
MI3	**pre-treatment**	46.11	48.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.74	39.63	0.00	0.00	0.00	0.00	0.00	0.00	1.05	3.15	0.32	1.16	87.21	57.86
MI3	**post-treatment**	54.05	47.21	0.00	0.00	0.16	0.37	0.00	0.00	0.00	0.00	57.32	43.02	1.84	6.06	0.00	0.00	0.00	0.00	3.00	3.11	0.68	1.06	117.05	63.39
MI7	**Control - 2002**	2.63	7.88	0.00	0.00	0.00	0.00	0.00	0.00	2.63	11.47	5.26	22.94	0.00	0.00	3.95	12.54	0.11	0.46	34.89	45.23	23.47	49.81	72.95	79.36
MI7	**Control - 2004**	5.37	22.92	0.00	0.00	0.00	0.00	0.00	0.00	5.32	22.93	12.37	25.35	20.26	31.99	4.16	12.50	0.21	0.92	29.53	45.48	14.37	37.45	91.58	88.76
SO1	**Control - 2001**	0.00	0.00	0.00	0.00	5.37	13.34	5.26	13.38	1.95	5.84	11.84	31.59	0.00	0.00	0.00	0.00	7.89	23.65	0.74	1.56	30.84	28.43	63.89	55.92
SO1	**Control - 2004**	0.00	0.00	0.00	0.00	23.82	38.13	0.00	0.00	3.53	8.16	10.29	26.37	0.00	0.00	3.06	12.11	12.24	26.80	39.82	44.94	103.12	100.57	195.88	144.89
SO2	**pre-treatment**	0.00	0.00	0.00	0.00	1.79	6.68	1.79	6.68	0.07	0.27	0.00	0.00	0.00	0.00	5.36	14.47	8.07	17.94	3.71	9.02	16.71	36.46	37.50	52.56
SO2	**post-treatment**	0.00	0.00	0.00	0.00	4.48	13.25	10.84	28.90	0.01	0.02	0.00	0.00	7.86	26.65	0.53	1.49	23.79	35.43	2.84	6.64	29.27	36.53	79.61	118.09
SO3	**pre-treatment**	0.00	0.00	0.00	0.00	5.26	22.94	1.32	5.74	1.32	5.74	0.00	0.00	0.00	0.00	9.32	25.25	2.63	7.88	0.16	0.37	5.53	10.35	25.53	52.71
SO3	**post-treatment**	0.00	0.00	0.00	0.00	2.53	6.01	0.00	0.00	1.32	5.74	0.00	0.00	1.32	5.74	8.11	23.59	2.89	7.87	0.11	0.46	6.00	13.78	22.26	42.21
SO4	**pre-treatment**	5.26	22.94	0.00	0.00	0.11	0.32	1.32	5.74	0.05	0.23	25.00	38.19	0.00	0.00	0.00	0.00	0.00	0.00	9.47	23.78	42.95	67.03	84.16	78.89
SO4	**post-treatment**	5.26	22.94	0.00	0.00	0.37	1.12	0.00	0.00	0.05	0.23	12.11	24.00	1.32	5.74	0.00	0.00	0.05	0.23	6.16	11.69	24.84	45.86	50.16	66.13

Species:

ANCA = ***Anemopsis californica***
ACRE = ***Acroptilon repens***
COCA = ***Conyza canadensis***
DESO = ***Descurainia sophia***
MEOF = ***Melilotus officinale***
MUAS = ***Muhlenbergia asperifolia***
PAOB = ***Panicum obtusem***
RATA = ***Ratibida tagetes***
SOEL = ***Solanum eleagnifolium***
SPsp = ***Sporabolis* grasses (*S. airoides, S. contractus, S. cryptandrus, S. flexuosus, S. giganteum, S. wrightii* and plants unidentified to species)**

Table 4. Changes in Native Shrubs After Clearing
(Mean Number of shrubs per 4-M Diameter plot)

SITE		BASF Mean	BASF SD	FOPU Mean	FOPU SD	GUSA Mean	GUSA SD	SAEX Mean	SAEX SD	Others Mean	Others SD	All Native Shrubs Mean	All Native Shrubs SD
NO1	Control - 2001	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.23	0.00	0.00	0.05	0.23
NO1	Control - 2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.23	0.05	0.23
NO2	pre-treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.81	0.26	0.81
NO2	post-treatment	0.00	0.00	0.24	0.56	0.00	0.00	0.12	0.49	1.00	2.74	1.35	2.74
NO3	pre-treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.24	0.06	0.24	0.12	0.33
NO3	post-treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO4	pre-treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.47	0.17	0.71	0.28	0.83
NO4	post-treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.95	0.05	0.23	0.37	0.96
MI1	pre-treatment	0.00	0.00	0.00	0.00	0.00	0.00	2.95	5.31	1.21	3.15	4.16	7.30
MI1	pre-treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.74	1.10	0.32	0.82	1.05	1.54
MI3	pre-treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MI3	post-treatment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MI7	Control - 2002	0.00	0.00	0.00	0.00	0.00	0.00	3.21	11.40	0.00	0.00	3.21	11.40
MI7	Control - 2004	0.00	0.00	0.00	0.00	0.00	0.00	1.58	2.57	0.05	0.23	1.63	2.54
SO1	Control - 2001	0.05	0.23	0.05	0.23	1.37	5.73	0.00	0.00	0.47	1.31	1.95	5.73
SO1	Control - 2004	0.00	0.00	0.00	0.00	5.00	13.93	0.00	0.00	1.24	1.79	6.24	13.71
SO2	pre-treatment	0.54	1.39	5.54	5.84	0.08	0.28	0.00	0.00	0.31	0.48	6.46	5.91
SO2	post-treatment	0.85	0.99	17.92	15.90	0.77	2.77	0.00	0.00	0.54	1.39	20.08	15.63
SO3	pre-treatment	1.21	1.75	3.00	7.85	0.00	0.00	0.00	0.00	0.47	1.43	4.68	7.43
SO3	post-treatment	2.37	4.18	0.79	2.10	0.05	0.23	0.00	0.00	0.58	1.35	3.79	4.38
SO4	pre-treatment	3.16	4.26	0.21	0.54	1.37	5.73	0.00	0.00	2.74	4.16	7.47	10.64
SO4	post-treatment	2.63	3.62	0.42	1.02	0.26	0.93	0.00	0.00	2.74	4.03	6.05	6.25

Species:
BASF = *Baccharis salicifolia*
FOPU = *Forestiera pubescens*
GUSA = *Gutierrezia sarothrae*
SAEX = *Salix exigua*
Others = *Amorpha fruticosa, Atriplex cansecens, Baccharis salicina, Chrysothamnus linifolius, Juniperus monosperma, Lycium pallidum, Prosopsis pubescens*

Figure 4. Large Exotic Plants (DBH >5 cm) on 4-M Diameter Plots Before and After Cutting (* = Control Plot)

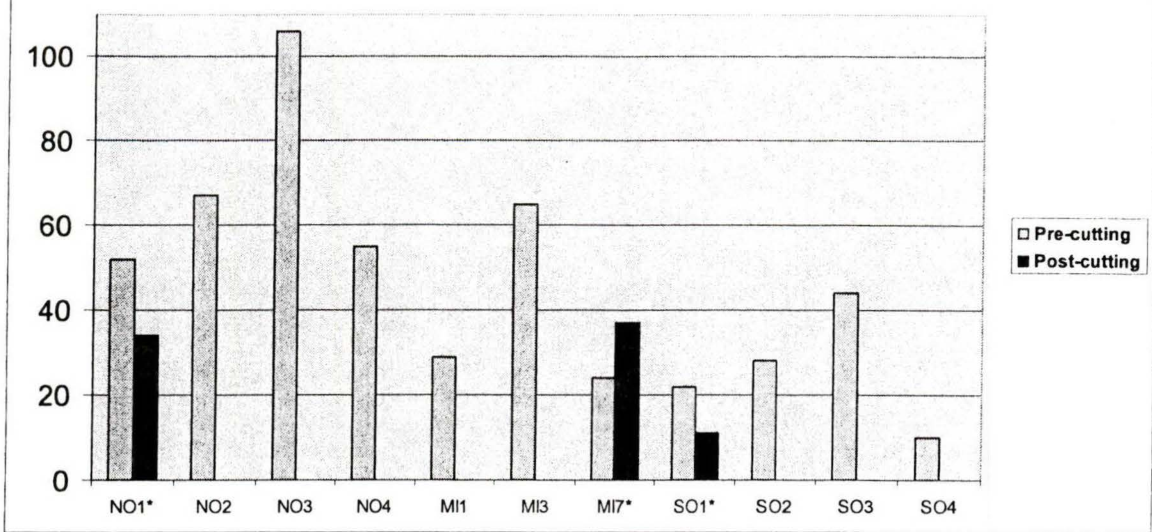
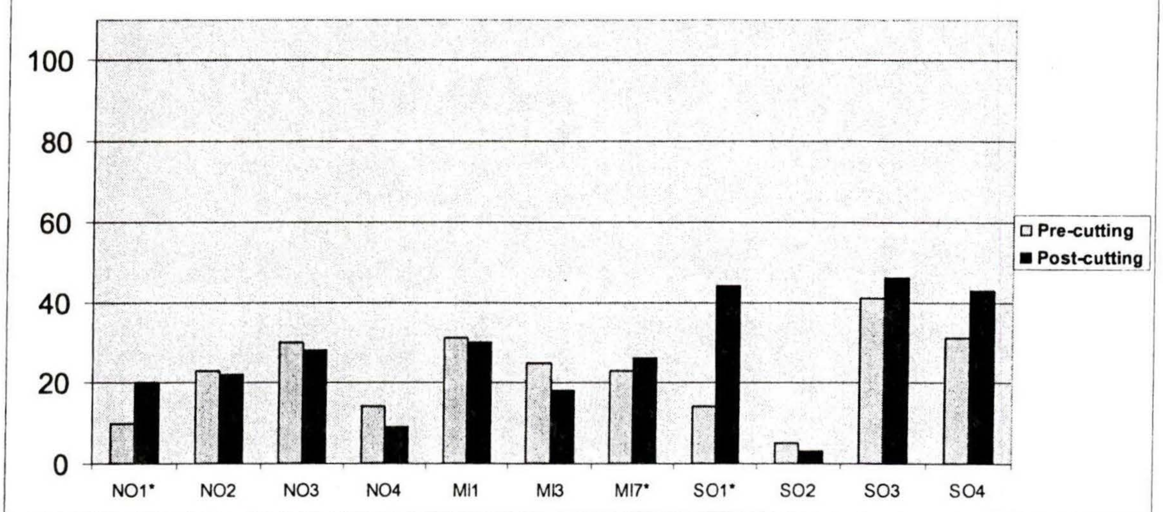


Figure 5. Large Native Plants (DBH >5 cm) on 4-M Diameter Plots Before and after Cutting (* = Control Plot)



trees (Figure 6). Some of the apparent changes on control plots are the result of slight changes in plot locations due to missing plot markers rather than actual changes in the habitat.

The number of small exotic woody plants (<5 cm DBH) also decreased markedly on the plots (Figure 7). Only 28% of the post-cutting survey plots recorded any small exotic woody plants compared to over 65% of the plots prior to cutting. The vast majority (>91%) of exotics found on post-cutting surveys were resprouts from cut stumps. These resprouts are smaller and far fewer than the number of plants prior to cutting and many of these were or will be removed by subsequent follow-up treatments. The few remaining exotic plants recorded on post-cutting surveys were either seedlings or uncut plants.

1-Meter Radius Stem Density Plots

As would be expected from the clearing, overall numbers of exotic woody stems declined substantially with the treatments (Figures 8 & 9). The 1-M plots produced samples sizes too small to draw any meaningful conclusions, although they do reflect the very high density of native shrubs at SO-2 relative to other study sites.

Ground Cover Transects

The ground cover transects showed the greatest changes related to treatments: a large increase in the amount of ground covered by wood chips. Most of the ground covered by wood chips following treatments was originally covered by litter. Treatments produced significant declines in litter on all treatment sites. SO-3, the only site where a controlled burn has been conducted thus far, had a threefold increase in the amount of bare ground on the site as a result of the fire. Plant cover of all types did not change appreciably for the most part. There were some significant changes at some plots, but no overall trends were clearly evident (Table 5). For example, MI-3 had a large increase in grass cover and a large decrease in forb cover, and a few sites had significant increases in shrub cover.

Dead and Downed Woody Debris Transects

M Radius Plots Before and After Cutting (* = Control Site)

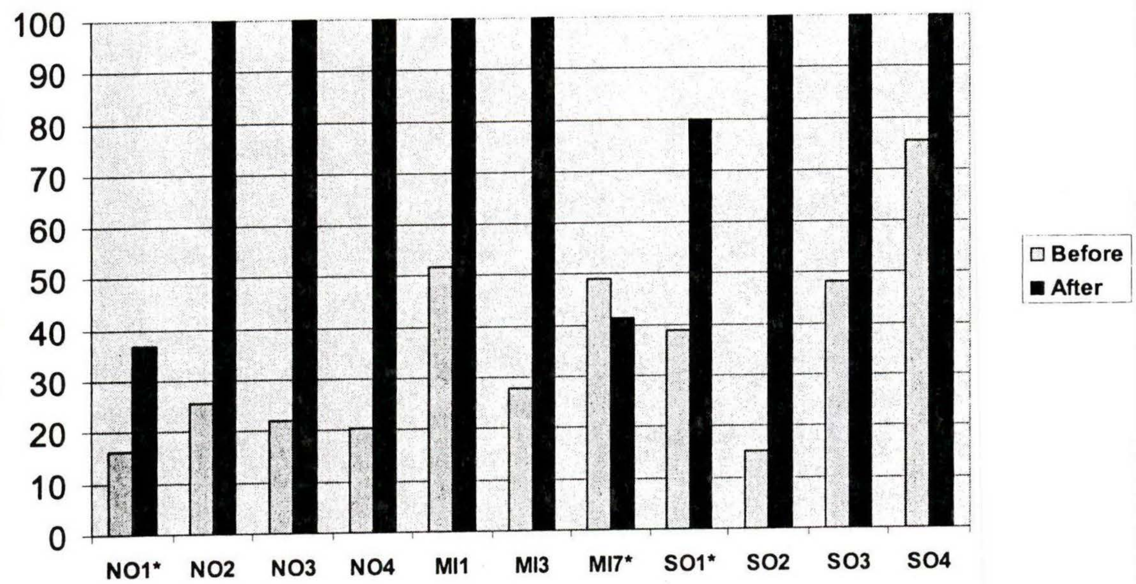
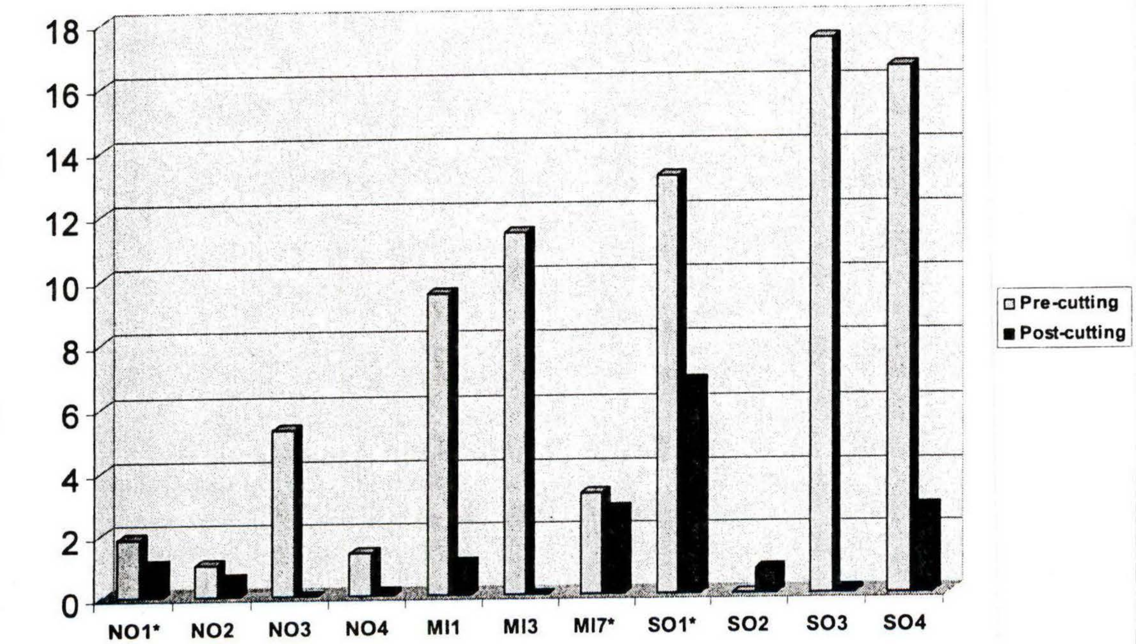


Figure 7. Mean Number of Live Small Exotic Plants (DBH <5cm) per 4-M Radius Plot
(* = control plot)



Radius Plots Prior to Cutting (* = Control Plot)

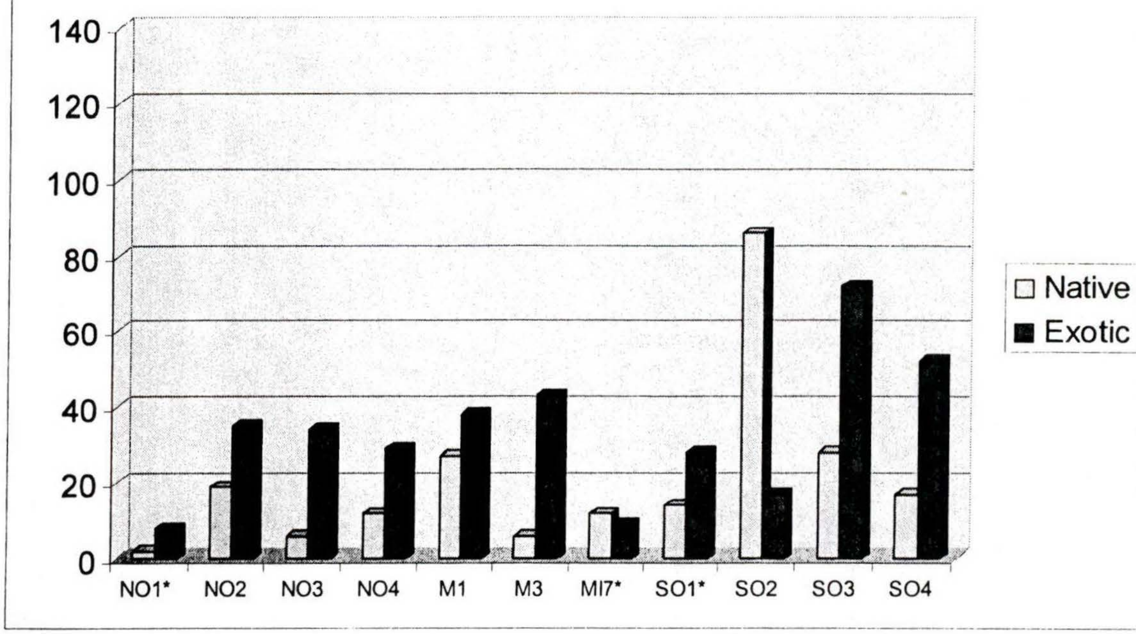


Figure 9. Stem Counts of Exotic and Native Woody Plants on 1-M Radius Plots After Cutting (* = Control Plot)

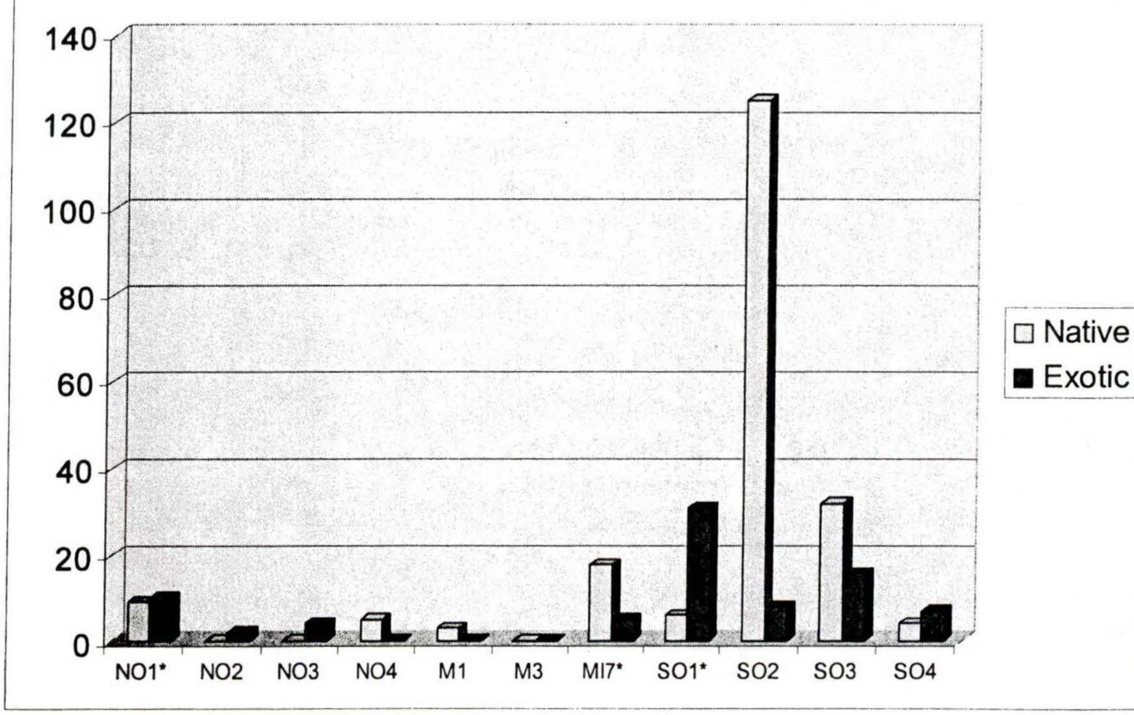


Table 5. Change in Mean per Cent Cover Types on Ground Cover Transects After Treatments
(Sites Significantly Different at .05 in Bold)

Site	Litter			Wood chips			Bare ground			Woody debris			Forbs			Grass			Shrubs			Trees			Other		
	Mean	SD	P-value	Mean	SD	P-value	Mean	SD	P-value	Mean	SD	P-value	Mean	SD	P-value	Mean	SD	P-value	Mean	SD	P-value	Mean	SD	P-value	Mean	SD	P-value
NO1 Control - 2002	85.64	9.07	0.041	0.00	0.00	N/A	1.09	1.87	0.356	10.00	6.26	0.017	0.36	1.21	0.504	0.36	1.21	0.672	0.18	0.60	0.023	0.36	0.81	0.683	2.00	5.44	0.251
NO1 Control - 2004	78.18	6.54		0.00	0.00		2.00	2.53		17.27	6.94		0.73	1.35		0.18	0.60		1.09	1.04		0.55	1.29		0.00	0.00	
NO2 pre-treatment	89.09	8.46	0.000	0.00	0.00	0.004	4.36	4.97	0.756	6.00	4.90	0.003	0.00	0.00	0.103	0.00	0.00	N/A	0.00	0.00	0.343	0.55	1.29	0.188	0.00	0.00	N/A
NO2 post-treatment	63.64	14.05		14.73	13.24		3.82	2.44		16.91	9.18		0.73	1.35		0.00	0.00		0.18	0.60		0.00	0.00		0.00	0.00	
NO3 pre-treatment	86.18	9.94	0.001	0.00	0.00	0.000	0.73	1.35	0.824	10.00	6.13	0.800	0.18	0.60	0.343	0.18	0.60	0.343	0.18	0.60	0.490	1.64	1.75	0.230	0.91	3.02	0.341
NO3 post-treatment	56.80	21.69		32.00	18.64		0.60	1.35		9.40	4.99		0.00	0.00		0.00	0.00		0.40	0.84		0.80	1.40		0.00	0.00	
NO4 pre-treatment	78.18	9.53	0.001	0.00	0.00	0.343	2.00	2.53	0.023	18.18	6.29	0.021	0.55	1.81	0.535	0.18	0.60	0.343	0.00	0.00	N/A	0.91	1.38	0.733	0.00	0.00	N/A
NO4 post-treatment	59.09	12.66		0.18	0.60		11.64	11.86		28.18	11.68		0.18	0.60		0.00	0.00		0.00	0.00		0.73	1.01		0.00	0.00	
MI1 pre-treatment	82.18	11.04	0.000	0.00	0.00	0.000	7.09	10.71	0.517	6.18	4.14	0.942	1.45	3.59	0.563	0.73	1.85	0.410	1.45	2.38	0.836	0.73	1.35	0.234	0.18	0.60	0.343
MI1 post-treatment	55.82	14.68		29.82	16.45		4.73	3.93		6.00	6.63		0.73	1.85		1.45	2.21		1.27	1.62		0.18	0.60		0.00	0.00	
MI3 pre-treatment	68.73	13.33	0.000	0.00	0.00	0.000	4.18	3.16	0.137	7.09	3.62	0.852	17.09	14.54	0.096	0.73	1.85	0.001	0.00	0.00	0.079	2.18	2.75	0.090	0.00	0.00	0.342
MI3 post-treatment	39.09	14.57		33.82	17.26		2.00	3.46		7.45	5.22		8.00	9.17		8.00	5.22		0.91	1.38		0.55	0.93		0.18	0.60	
MI7 Control - 2002	67.82	15.11	0.444	0.00	0.00	N/A	4.00	8.20	0.953	11.09	5.68	0.515	4.18	6.66	0.117	9.45	10.00	0.875	0.18	0.60	0.065	3.27	3.72	0.024	0.00	0.00	N/A
MI7 Control - 2004	72.00	9.92		0.00	0.00		4.18	5.69		12.91	7.06		0.73	1.85		8.73	11.29		1.27	1.62		0.18	0.60		0.00	0.00	
SO1 Control - 2002	62.00	22.80	0.025	0.00	0.00	N/A	27.82	20.66	0.238	3.09	3.02	0.580	0.55	1.29	0.033	1.27	3.00	0.275	0.00	0.00	0.010	0.73	1.01	0.407	4.55	5.66	0.601
SO1 Control - 2004	41.80	14.68		0.00	0.00		36.80	12.34		4.00	4.52		7.20	8.60		3.00	4.03		3.40	3.53		0.40	0.84		3.40	4.22	
SO2 pre-treatment	77.50	10.57	0.001	0.00	0.00	0.019	12.75	11.16	0.666	8.50	5.21	0.419	0.00	0.00	0.180	0.50	0.93	0.460	0.50	0.93	0.009	0.25	0.71	0.270	0.00	0.00	N/A
SO2 post-treatment	53.75	17.05		7.75	9.16		10.50	13.17		10.50	6.30		2.75	6.32		1.50	4.24		13.25	12.91		0.00	0.00		0.00	0.00	
SO3 pre-treatment	83.09	13.34	0.007	0.00	0.00	N/A	7.27	11.11	0.003	8.18	4.85	0.729	0.18	0.60	0.405	0.18	0.60	1.000	0.00	0.00	0.011	1.09	1.38	0.763	0.00	0.00	0.171
SO3 post-treatment	67.27	10.78		0.00	0.00		21.64	9.37		7.45	4.91		0.55	1.29		0.18	0.60		1.64	1.75		0.91	1.38		0.36	0.81	
SO4 pre-treatment	80.91	9.97	0.001	0.00	0.00	0.008	5.64	5.64	0.650	8.55	3.91	0.032	0.18	0.60	0.368	3.27	4.22	0.873	0.36	1.21	0.226	1.09	1.87	0.416	0.00	0.00	0.343
SO4 post-treatment	60.36	14.64		11.82	11.85		4.73	3.26		16.36	10.03		1.09	3.02		3.64	6.44		1.27	2.05		0.55	0.93		0.18	0.60	

The fuels removal treatments greatly reduced the total amount of dead woody materiel on all treated sites, particularly above the ground level as measured by the woody debris transects (Table 6). At ground level, only about half the treated sites showed significant decreases. Nearly all of the increase in medium and large wood pieces on treated sites is a temporary increase due to preliminary steps of the treatment process (e. g., firewood piles that had not yet been removed at the time surveys were done).

Fuels Transects

The fuels reduction treatments removed essentially all standing exotic fuels. In 2004, fuels transects were conducted counting wood chips from the treatment process. In 2005, transects will be counted without counting the wood chips to compare differences in the fuel load estimates by these two methods.

Fuel transect data are still being analyzed. We expect a new update of the Fuels Manager Program to be released shortly that we plan to use to analyze our data. In the past, fuels calculations were performed using substitute species available in the Fuels program that most closely resembled southwestern species, the new program will recalculate original and new fuel load using the updated program.

Bird Survey Results

Each bird census point on all 12 study sites was surveyed at least 4 times during the 2004 breeding season to monitor the effects of treatments on breeding bird populations. Eight-minute counts were conducted at each station in the early morning hours from May 10th to July 21st on days with favorable weather conditions. Surveys were conducted using the same protocols established for previous year's surveys.

Table 6. Changes in Dead and Downed Woody Debris on Sites (Mean Number of Pieces per 50 - Meter Transect by Height Level)

Small Pieces (2-5 cm in diameter)

SITE		Level 1			Level 2			Level 3			Level 4		
		Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value
NO1	Control - 2000	34.45	15.76	0.013	10.36	8.24	0.149	4.18	3.63	0.401	1.91	2.07	0.063
NO1	Control - 2004	53.27	29.81		6.18	3.76		2.73	4.41		0.55	0.89	
NO2	pre-treatment	28.18	10.78	0.118	7.64	6.86	0.006	8.00	4.20	0.000	5.09	4.81	0.008
NO2	post-treatment	44.82	30.24		0.27	0.90		0.00	0.00		0.00	0.00	
NO3	pre-treatment	36.00	15.96	0.849	15.27	13.05	0.005	4.64	4.11	0.008	5.09	8.32	0.036
NO3	post-treatment	34.60	16.52		0.10	0.32		0.20	0.42		0.10	0.32	
NO4	pre-treatment	33.09	18.03	0.003	7.09	4.23	0.000	3.82	4.77	0.024	1.27	1.90	0.051
NO4	post-treatment	66.91	27.59		0.00	0.00		0.00	0.00		0.00	0.00	
MI1	pre-treatment	28.00	14.95	0.989	7.82	7.70	0.007	1.64	1.36	0.003	1.91	2.88	0.039
MI1	post-treatment	28.09	15.86		0.00	0.00		0.00	0.00		0.00	0.00	
MI3	pre-treatment	24.18	10.39	0.372	7.45	6.28	0.003	4.18	3.92	0.005	3.55	2.81	0.002
MI3	post-treatment	20.82	6.82		0.00	0.00		0.00	0.00		0.00	0.00	
MI7	Control - 2002	23.73	12.55	0.648	2.27	1.86	0.025	1.91	2.26	0.346	2.55	2.86	0.405
MI7	Control - 2004	26.55	15.71		5.18	3.40		1.09	1.64		1.64	2.38	
SO1	Control - 2000	18.82	13.17	0.303	1.91	2.43	0.820	3.36	5.22	0.420	0.73	1.19	0.757
SO1	Control - 2004	13.50	10.27		2.20	3.33		1.90	2.47		0.90	1.37	
SO2	pre-treatment	30.75	8.22	0.372	2.75	3.28	0.941	1.00	1.69	0.261	0.25	0.46	0.168
SO2	post-treatment	41.25	30.28		2.63	3.11		0.25	0.46		0.00	0.00	
SO3	pre-treatment	44.73	9.33	0.001	5.91	5.13	0.014	3.73	3.20	0.006	1.82	1.72	0.019
SO3	post-treatment	23.09	15.59		1.00	1.90		0.36	0.67		0.27	0.90	
SO4	pre-treatment	25.36	11.47	0.966	3.09	4.21	0.131	1.64	2.42	0.153	0.73	1.42	0.170
SO4	post-treatment	25.09	17.33		0.91	1.81		0.45	0.82		0.09	0.30	

Medium Pieces (5-20 cm in diameter)

SITE		Level 1			Level 2			Level 3			Level 4		
		Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value
NO1	Control - 2000	12.91	10.03	0.345	4.18	2.86	0.477	2.27	1.85	0.215	0.18	0.40	0.280
NO1	Control - 2004	9.45	6.65		3.18	3.54		1.18	2.18		0.82	1.83	
NO2	pre-treatment	7.09	4.74	0.103	1.27	1.49	0.016	1.36	1.43	0.010	1.18	1.25	0.011
NO2	post-treatment	14.73	13.25		0.00	0.00		0.00	0.00		0.00	0.00	
NO3	pre-treatment	10.18	5.76	0.782	3.55	3.56	0.012	1.64	1.43	0.008	0.73	1.10	0.065
NO3	post-treatment	9.20	9.45		0.00	0.00		0.10	0.32		0.00	0.00	
NO4	pre-treatment	15.55	8.15	0.000	8.36	9.84	0.018	2.18	1.94	0.004	0.45	1.04	0.182
NO4	post-treatment	33.91	11.27		0.00	0.00		0.00	0.00		0.00	0.00	
MI1	pre-treatment	3.91	4.41	0.887	1.00	1.26	0.025	0.36	0.67	0.105	0.09	0.30	0.343
MI1	post-treatment	4.18	4.35		0.00	0.00		0.00	0.00		0.00	0.00	
MI3	pre-treatment	9.45	4.87	0.033	3.27	3.35	0.009	1.09	1.81	0.074	1.36	1.29	0.006
MI3	post-treatment	5.18	3.79		0.00	0.00		0.00	0.00		0.00	0.00	
MI7	Control - 2002	6.00	2.76	0.200	2.18	1.54	0.501	1.55	1.57	0.014	1.27	1.79	0.062
MI7	Control - 2004	4.45	2.73		1.64	2.06		0.18	0.40		0.09	0.30	
SO1	Control - 2000	4.00	4.12	0.158	0.45	1.51	0.929	0.18	0.60	0.375	0.00	0.00	0.087
SO1	Control - 2004	1.90	2.33		0.40	0.97		0.80	2.20		0.40	0.70	
SO2	pre-treatment	4.13	1.89	0.204	0.88	1.73	0.456	0.13	0.35	0.325	0.25	0.46	0.168
SO2	post-treatment	7.25	5.92		0.38	0.74		0.00	0.00		0.00	0.00	
SO3	pre-treatment	12.82	7.39	0.002	1.27	1.01	0.002	1.27	1.42	0.028	0.55	0.89	0.026
SO3	post-treatment	3.09	3.81		0.00	0.00		0.18	0.40		0.00	0.00	
SO4	pre-treatment	9.73	4.27	0.141	1.00	2.10	0.193	0.45	1.04	0.182	0.27	0.85	0.198
SO4	post-treatment	6.55	5.35		0.09	0.30		0.00	0.00		0.00	0.00	

Large Pieces (>20 cm in diameter)

SITE		Level 1			Level 2			Level 3			Level 4		
		Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value
NO1	Control - 2000	0.91	0.94	0.231	0.09	0.30	0.567	0.00	0.00	N/A	0.09	0.30	0.343
NO1	Control - 2004	0.45	0.82		0.18	0.40		0.00	0.00		0.00	0.00	
NO2	pre-treatment	0.55	0.82	0.629	0.00	0.00	N/A	0.09	0.30	0.343	0.00	0.00	N/A
NO2	post-treatment	0.91	2.39		0.00	0.00		0.00	0.00		0.00	0.00	
NO3	pre-treatment	0.82	0.87	0.422	0.45	0.89	0.183	0.18	0.60	0.368	0.00	0.00	N/A
NO3	post-treatment	1.30	1.64		0.10	0.32		0.00	0.00		0.00	0.00	
NO4	pre-treatment	1.91	1.38	0.601	0.09	0.30	0.343	0.18	0.40	0.166	0.00	0.00	N/A
NO4	post-treatment	2.36	2.46		0.00	0.00		0.00	0.00		0.00	0.00	
MI1	pre-treatment	0.09	0.30	0.343	0.00	0.00	N/A	0.00	0.00	N/A	0.00	0.00	N/A
MI1	post-treatment	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
MI3	pre-treatment	0.45	1.21	0.663	0.00	0.00	0.343	0.00	0.00	N/A	0.00	0.00	N/A
MI3	post-treatment	0.27	0.65		0.09	0.30		0.00	0.00		0.00	0.00	
MI7	Control - 2002	0.64	1.03	1.000	0.00	0.00	0.343	0.09	0.30	0.343	0.00	0.00	N/A
MI7	Control - 2004	0.64	1.12		0.09	0.30		0.00	0.00		0.00	0.00	
SO1	Control - 2000	0.09	0.30	0.192	0.00	0.00	N/A	0.00	0.00	N/A	0.00	0.00	N/A
SO1	Control - 2004	0.40	0.70		0.00	0.00		0.00	0.00		0.00	0.00	
SO2	pre-treatment	1.25	0.89	0.403	0.50	0.53	0.326	0.00	0.00	N/A	0.00	0.00	N/A
SO2	post-treatment	0.88	0.83		0.25	0.46		0.00	0.00		0.00	0.00	
SO3	pre-treatment	0.45	0.69	0.279	0.00	0.00	N/A	0.00	0.00	N/A	0.00	0.00	N/A
SO3	post-treatment	0.18	0.40		0.00	0.00		0.00	0.00		0.00	0.00	
SO4	pre-treatment	0.82	1.08	0.557	0.09	0.30	0.343	0.00	0.00	N/A	0.09	0.30	0.343
SO4	post-treatment	0.55	1.04		0.00	0.00		0.00	0.00		0.00	0.00	

Level 1 = 0 - 0.5 M above ground
Level 2 = 0.5 - 1.0 M above ground
Level 3 = 1.0 - 1.5 M above ground
Level 4 = 1.5 - 2.0 M above ground

Just over 5400 birds of 90 species were recorded on surveys this field season. As they have been in previous years, Black-chinned Hummingbirds (see Appendix 2 for scientific names) were the most frequently detected species by a wide margin. The four next most commonly recorded species were: Black-headed Grosbeak, Ash-throated Flycatcher, Mourning Dove and Bewick's Wren. Ten common breeding species that have been the most commonly recorded species in the past made up more than 65% of all birds detected on the surveys this season (Tables 6 & 7). As in the past, certain species displayed distinct patterns in the locations where they were found. Lucy's Warbler, Phainopepla and Yellow-billed Cuckoo were found almost exclusively at sites further south while species such as Black-capped Chickadee and American Crow were largely confined to the northern sites.

Six species not previously recorded on surveys were detected this year, bringing the total number of species recorded on surveys during the study to 129. Two species (Mississippi Kite and Lesser Nighthawk) are known to breed in the Middle Rio Grande Valley while the other four (Long-billed Curlew, Olive-sided Flycatcher, Cedar Waxwing, and Black-throated Gray Warbler) were likely only spring migrants in this area (Appendix 3).

For the most part, total observations of bird species and total observations of individuals detected on the 2004 surveys declined on cut sites and remained about the same on control plots compared to 2003. Bird numbers at all sites were below their highest levels recorded (in 2002 or 2003), but above the numbers recorded in the first two years of the study (Figures 10 & 11). SO-2, a site having the highest amount of native understory vegetation of all the sites, has typically had the highest numbers and most species of birds across years. All five transects that were cut two winters ago had fewer birds per survey effort in the 2nd breeding season after cutting. The first breeding season after cutting produced mixed results. Numbers of birds increased on some sites and decreased on other sites. Some apparent increases may be a function of increased detectability over greater distances rather than actual increases.

Table 7. Non-Passerine Birds Detected on MRG Fuels Reduction Sites Surveys - May-July 2004

SPECIES	NO1	NO2	NO3	NO4	MI1	MI2	MI3	MI7	SO1	SO2	SO3	SO4	TOTAL
Canada Goose	3	4	3	18						2			**30**
Wood Duck	1		3	1					2				**7**
Mallard	6	8	11	8	5	7	1	7	4	11	3	4	**75**
Northern Pintail	2			2									**4**
Ring-necked Pheasant	24	12	6	12	1	6	2	12			6	10	**91**
Wild Turkey											2		**2**
Gambel's Quail	1	2									11	2	**16**
Peacock (exotic)			1										**1**
Great Blue Heron		1								1			**2**
Great Egret			1			1	1						**3**
Snowy Egret			4		3	2							**9**
Cattle Egret	1				1								**2**
Green Heron			1			2					1		**4**
Black-crowned Night-Heron	4		1										**5**
Turkey Vulture			1	2	3					4			**10**
Mississippi Kite					1								**1**
Cooper's Hawk	8	4		4	4	1		3		5			**29**
Swainson's Hawk			3	3			2	3			1		**12**
American Kestrel				1			3	2		5	4	5	**20**
Killdeer	1	1	4	1	1		2				5	2	**17**
Spotted Sandpiper	1		2		1		1	1	3				**9**
Long-billed Curlew												1	**1**
Rock Pigeon					7	11							**18**
White-winged Dove										3			**3**
Mourning Dove	16	31	17	29	15	27	49	40	36	34	29	43	**366**
Yellow-billed Cuckoo							1				6	2	**9**
Greater Roadrunner	2					1		1				1	**5**
Great Horned Owl						1	1	1				4	**7**
Lesser Nighthawk												1	**1**
Common Nighthawk												2	**2**
Black-chinned Hummingbird	120	102	43	57	98	66	43	58	39	21	6	9	**662**
Broad-tailed Hummingbird			1		1				2				**4**
Belted Kingfisher			1				1	1					**3**
Ladder-backed Woodpecker										3	9	9	**21**
Downy Woodpecker	5	16	10	9	11	8	5	5	3	2	6	4	**84**
Hairy Woodpecker	3	1		2		4	3	1	2	4	2	4	**26**
Northern "Red-shafted" Flicker	13	2	4	4	4	7	21	11	1	1	2	3	**73**

Table 8. Passerine Birds Detected on MRG Fuels Reduction Sites Surveys - May-July 2004

SPECIES	NO1	NO2	NO3	NO4	MI1	MI2	MI3	MI7	SO1	SO2	SO3	SO4	TOTAL
Olive-sided Flycatcher				1							1		2
Western Wood-Pewee	2	13	34	28	7	9	25	1	13	3	3	2	140
Dusky Flycatcher									1			1	2
Black Phoebe		1	4		1		2		1		1	1	11
Say's Phoebe		1											1
Ash-throated Flycatcher	43	22	25	30	45	35	30	40	54	21	50	60	455
Western Kingbird	2		2		2		9	3			5	5	28
Warbling Vireo	1	1								1	1	2	6
American Crow	2	3			3	2							10
Chihuahuan Raven										4		2	6
Common Raven		1		1						8	2	2	14
Violet-green Swallow	2		7										9
Northern Rough-winged Swallow			7			4	1			1			13
Bank Swallow										3			3
Cliff Swallow		3						2	1		2	1	9
Barn Swallow	6		7		5		7	1	9		1		36
Black-capped Chickadee	21	24	14	11	16	10	8	20	1	2			127
Bushtit	7	3	5		5		1	2			1		24
White-breasted Nuthatch	30	26	15	24	12	7	14	12	11	11	3	4	169
Bewick's Wren	44	37	15	14	24	21	17	26	22	36	9	45	310
House Wren										1			1
American Robin	13	6	8	3	2	2	3	3			1		41
Gray Catbird			1	1		1		1	2	5		3	14
Northern Mockingbird												1	1
European Starling	2	2	2		4		4	3					17
Cedar Waxwing								4					4
Phainopepla										24	5		29
Lucy's Warbler				4					19	8	13	31	75
Yellow-rumped "Audubon's" Warbler	2							2	4	1	2	1	12
Black-throated Gray Warbler									1				1
Northern Waterthrush												2	2
Common Yellowthroat	6	4	4	5	16	4	1	4	1	11	2	7	65
Hooded Warbler										1			1
Wilson's Warbler							1		1				2
Yellow-breasted Chat	34	25	13	16	18	18	9	11	19	57	31	23	274
Summer Tanager	26	25	20	33	19	14	24	17	7	15	26	35	261
Western Tanager	3			1		2							6
Spotted Towhee	29	63	20	25	24	35	29	37	19	23	14	24	342
Chipping Sparrow	3								1		1		5
Lark Sparrow									1				1
Black-headed Grosbeak	48	62	29	32	38	32	40	46	47	28	35	14	451
Blue Grosbeak	11	16	10	9	17	19	26	3	29	21	28	23	212
Lazuli Bunting	1	4						1					6
Indigo Bunting	1	6	2	1	3				1				14
Red-winged Blackbird	1		3	3	27	5	16	11	5	6	16	3	96
Western Meadowlark	1		1	1	5		4	11			1	1	25
Common Grackle											1		1
Great-tailed Grackle							2						2
Brown-headed Cowbird	17	14	20	11	27	13	21	22	34	36	45	18	278
Bullock's Oriole	1		1	1	2	3	1	3	5	3	5	7	32
House Finch	17	8	1	2		9	4	2	2	13	13	12	83
Lesser Goldfinch	2	2			1	18	6	2	3	2	5	2	43
House Sparrow		2			10								12
Total Individuals (includes non-passerines)	589	558	387	410	489	407	441	436	406	441	416	438	5418
Total Species (includes non-passerines)	47	38	45	38	40	35	41	41	37	40	45	45	90

Figure 10a. Mean Number of Bird Species Detected per Survey Point at North Block Sites, 2000-2004

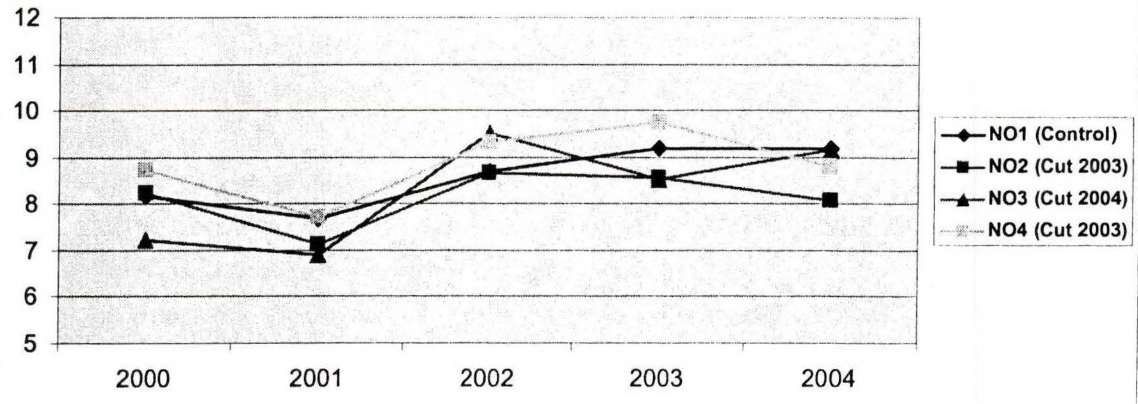


Figure 10b. Mean Number of Bird Species Detected per Survey Point at Middle Block Sites, 2000-2004

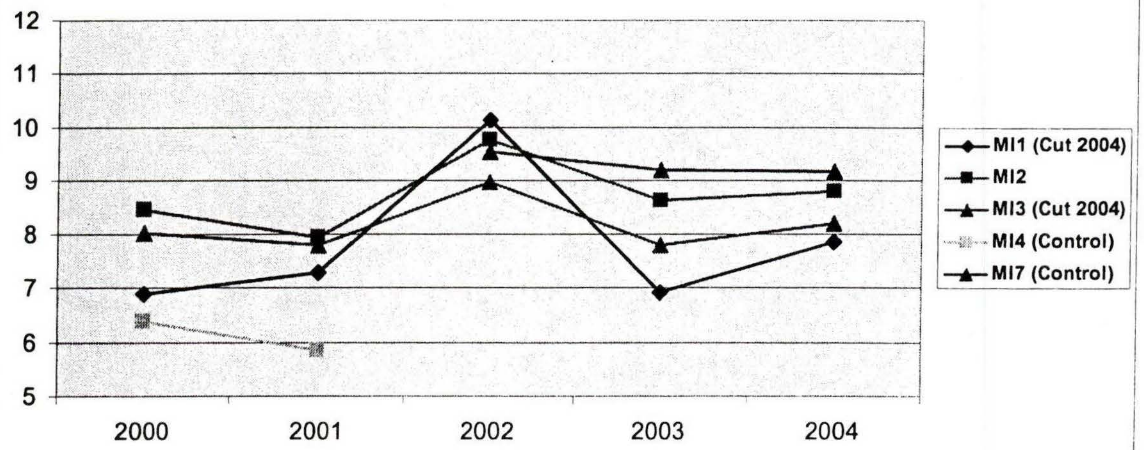


Figure10c. Mean Nunber of Bird Species Detected per Survey Point at South Block Sites, 2000-2004

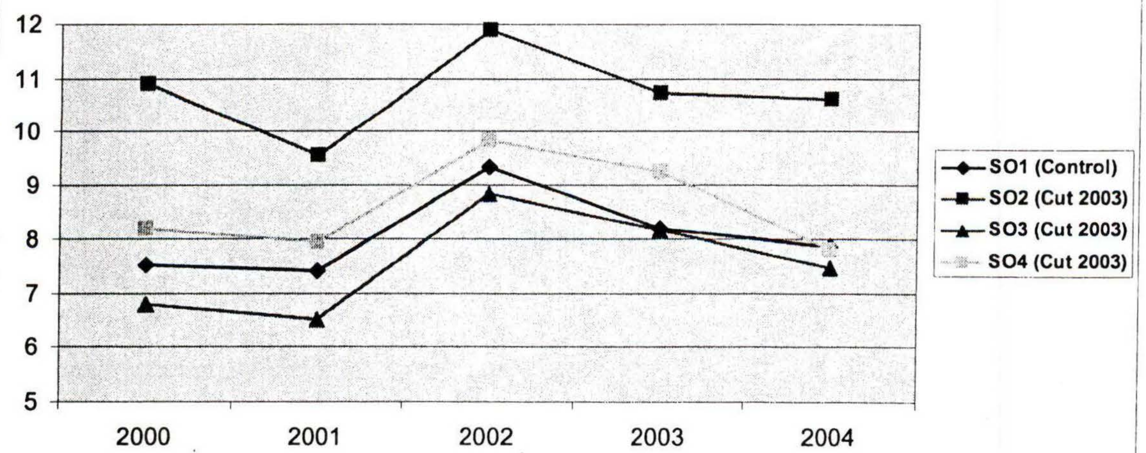


Figure 11a. Mean Number of Birds Detected per Survey Point at North Block Sites, 2000-2004

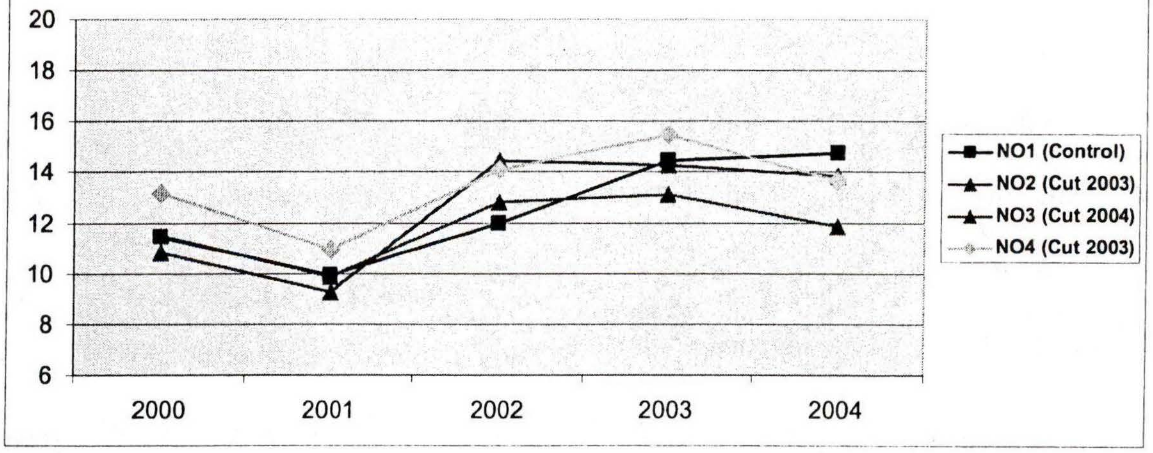


Figure 11b. Mean Number of Birds Detected per Survey Point at Middle Block Sites, 2000-2004

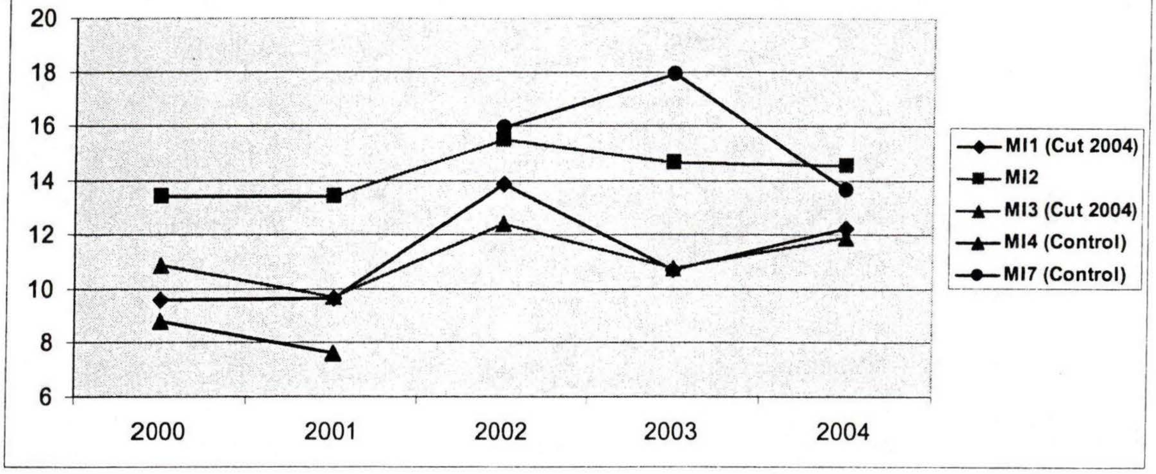
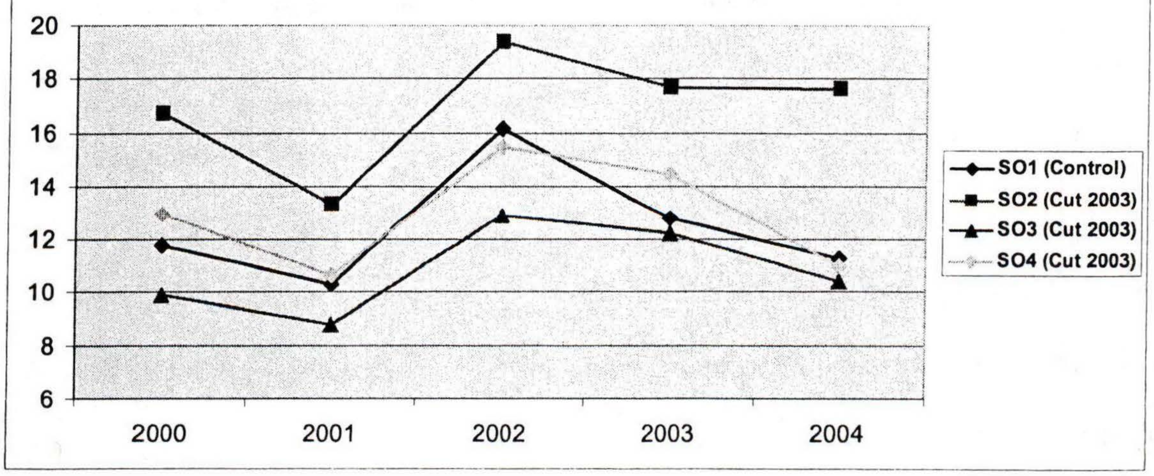


Figure 11c. Mean Number of Birds Detected per Survey Point at South Block Sites, 2000-2004



One notable exception to the overall slight downward trend in bird numbers was the dramatic decline in corvids observed during the 2004 field season. Corvids have been found to be especially susceptible to West Nile virus (Bernard et. al 2001) and we theorize the precipitous drop in these species this field season may be due to the recent appearance in New Mexico of the virus. Compared to the average number detected in the first 4 years of the study, numbers of observations of American Crows were down 90% and observations of Common Ravens were down 63% in 2004. In addition, no Black-billed Magpies were seen in 2004, although they have previously been present in small numbers on the North sites.

Some changes in bird numbers associated with treatments were noticeable from this year's data. Species such as the Spotted Towhee (Greenlaw 1996), which favor habitats with a large, well-developed understory, were less common on surveys for the 2nd consecutive post-treatment field season compared to surveys conducted prior to treatment. Mean numbers of Spotted Towhees detected on all five sites treated two years ago were lower than before treatments (Table 9).

At the other end of the spectrum, some species, such as Mourning Doves, Ash-throated Flycatchers and White-breasted Nuthatches appear to have responded favorably to exotics removal. These species were observed more frequently after clearing than prior to clearing. Mourning Doves are likely more common on cleared sites than intact sites because the decreased shrub cover provides greater foraging space (Mirarchi & Baskett 1994). Ash-throated Flycatchers, too, may also benefit from more open habitats which provided increased areas for aerial foraging (Cardiff & Dittman 2002). We are not sure what benefits more open habitats would have for White-breasted Nuthatches such that their numbers would increase. It is possible that perceived increases for species such as nuthatches are due more to the greater detectability of canopy-using birds when the understory is removed than because habitat conditions have improved for them. Analysis of multiple post-treatment years of data will be necessary to determine actual responses to treatments.

Table 9. Mean Number of Common Nesting Birds Detected per Survey Point Before and After Cutting

	NO-2				NO-4				SO-2				SO-3				SO-4			
	pre-cutting		post-cutting		pre-cutting		post-cutting		pre-cutting		post-cutting		pre-cutting		post-cutting		pre-cutting		post-cutting	
SPECIES	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cooper's Hawk	0.152	0.379	0.103	0.342	0.086	0.364	0.123	0.367	0.105	0.338	0.113	0.375	0.031	0.175	0.013	0.112	0.006	0.079	0.000	0.000
American Kestrel	0.007	0.081	0.000	0.000	0.013	0.115	0.111	0.387	0.162	0.370	0.264	0.524	0.000	0.000	0.088	0.326	0.056	0.231	0.100	0.341
Mourning Dove	0.338	0.576	0.494	0.776	0.636	0.761	0.926	1.034	0.990	1.005	1.151	1.133	0.725	0.808	0.863	0.924	0.994	0.974	1.388	1.049
Yellow-billed Cuckoo	0.040	0.227	0.000	0.000	0.007	0.081	0.000	0.000	0.029	0.167	0.075	0.385	0.150	0.407	0.163	0.489	0.088	0.305	0.050	0.219
Black-chinned Hummingbird	2.139	0.938	2.172	1.296	1.828	1.044	2.432	1.573	0.905	0.803	0.887	0.847	0.513	0.682	0.288	0.556	0.144	0.432	0.163	0.404
Downy Woodpecker	0.106	0.330	0.241	0.528	0.265	0.562	0.210	0.493	0.057	0.271	0.075	0.267	0.075	0.308	0.100	0.439	0.063	0.243	0.125	0.402
Northern "Red-shafted" Flicker	0.238	0.472	0.149	0.359	0.119	0.364	0.173	0.441	0.457	0.621	0.132	0.482	0.063	0.267	0.075	0.265	0.356	0.704	0.075	0.309
Western Wood-Pewee	0.079	0.295	0.287	0.645	0.457	0.728	0.938	0.940	0.324	0.563	0.245	0.434	0.119	0.378	0.138	0.443	0.213	0.554	0.188	0.480
Ash-throated Flycatcher	0.291	0.573	0.529	0.696	0.364	0.638	0.630	0.901	0.914	0.952	0.679	0.803	0.706	0.844	1.250	0.948	1.419	1.049	1.525	1.201
American Crow	0.166	0.482	0.149	0.495	0.252	0.613	0.173	0.543	0.143	0.562	0.000	0.000	0.019	0.136	0.013	0.112	0.038	0.272	0.013	0.112
Black-capped Chickadee	0.338	0.738	0.391	0.671	0.219	0.515	0.222	0.570	0.000	0.000	0.038	0.275	0.006	0.079	0.025	0.157	0.000	0.000	0.000	0.000
White-breasted Nuthatch	0.397	0.601	0.724	0.973	0.450	0.618	0.765	0.826	0.267	0.505	0.340	0.649	0.044	0.205	0.050	0.219	0.050	0.246	0.138	0.443
Bewick's Wren	0.881	0.799	0.713	0.776	1.060	0.785	0.778	0.908	0.933	0.824	1.264	1.095	0.644	0.730	0.450	0.692	1.544	0.990	1.450	0.940
Phainopepla	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.238	1.673	1.170	1.267	0.019	0.176	0.113	0.551	0.006	0.079	0.038	0.249
Lucy's Warbler	0.000	0.000	0.000	0.000	0.000	0.000	0.062	0.289	0.143	0.469	0.358	0.710	0.094	0.333	0.263	0.522	0.275	0.501	0.700	0.920
Yellow-breasted Chat	0.682	0.752	0.713	0.875	0.305	0.490	0.494	0.691	1.695	1.001	2.415	1.064	0.919	1.099	0.725	0.779	0.769	0.878	0.488	0.711
Summer Tanager	0.371	0.607	0.448	0.711	0.490	0.747	0.938	0.966	0.705	0.771	0.547	0.748	0.550	0.783	0.625	0.817	0.694	0.839	0.838	0.849
Spotted Towhee	1.450	0.984	1.264	0.982	1.364	0.956	0.938	0.927	1.743	0.991	1.189	1.001	1.094	0.983	0.375	0.582	1.094	1.014	0.800	0.933
Black-headed Grosbeak	1.291	0.853	1.379	0.839	1.642	0.982	1.111	1.037	0.848	0.818	1.170	1.122	0.756	0.867	0.775	0.795	0.500	0.654	0.275	0.551
Blue Grosbeak	0.325	0.536	0.287	0.504	0.185	0.468	0.358	0.598	0.838	0.982	0.962	1.055	0.625	0.845	0.725	0.927	0.438	0.741	0.413	0.688
Brown-headed Cowbird	0.344	0.684	0.586	0.829	0.556	0.907	0.654	1.027	0.990	1.252	1.245	1.017	0.763	1.130	0.850	1.213	1.219	1.169	0.650	0.982
House Finch	0.007	0.081	0.103	0.432	0.020	0.140	0.049	0.218	0.314	0.640	0.377	0.765	0.150	0.407	0.250	0.684	0.163	0.447	0.313	0.851

It also remains to be seen, if in the long term, the reduced availability of nesting sites for species such as Mourning Doves causes declines later on.

So far, most species have not shown a consistent trend towards increased or decreased numbers resulting from the treatment process. Some species may be responding to short-term changes in conditions which may or may not be related to treatments. We suggest it is too soon after treatment to report significant responses. More rigorous analysis, including the use of program DISTANCE, will be conducted in the future to further explore population changes.

Nest Monitoring

Each study site was regularly searched for nests two to three times per week throughout the primary breeding season from mid-May to early August. A few other nests were located by chance while doing other field work before or after the main breeding season, and these were monitored as well. The earliest nest located was a Great Horned Owl nest found on MI-7 on February 25th and latest was a Lesser Goldfinch nest found on NO-3 on August 17th.

All nests were monitored at regular intervals until either: the nestlings fledged; the nest was destroyed; or until 3 or more consecutive visits failed to detect any signs of activity. At the conclusion of the breeding season, additional measurements and observations were conducted at each nest to help characterize preferred nesting habitat for each species. These included nest substrate, nest height, nesting materials used, and various other measurements to help characterize nesting preferences. The additional nest data were collected in the same manner as in previous field seasons.

242 nests of 29 species were located during the 2004 field season. Of these, we were able to determine the fate of 196 nests. About 71% of these were believed to be successful, which is similar to previous years (Tables 10, 11 & 12). We found fewer nests in 2004 than in 2003 or 2002

Table 10. Nests Monitored at MRG North Fuels Reduction Sites - 2004

Species	Site NO1	Site NO2	Site NO3	Site NO4	Nest Fates Successful	Nest Fates Failed	Nest Fates Unknown	Total	% Successful *
Cooper's Hawk	1S	2F	1S	2S	4	2	0	6	66.67
Swainson's Hawk	0	0	0	1S	1	0	0	1	100.00
Ring-necked Pheasant	0	1S	0	0	1	0	0	1	100.00
Mourning Dove	1U	1U	1U	0	0	0	3	3	0.00
Great Horned Owl	0	1S	0	0	1	0	0	1	100.00
Black-chinned Hummingbird	13S/3U	2S/4F/1U	1S/3F/1U	9S/5F/2U	25	12	7	44	67.57
Downy Woodpecker	1S	3S	1S	3S	8	0	0	8	100.00
Hairy Woodpecker	0	1S	0	1S	2	0	0	2	100.00
Northern Flicker	2S	0	0	0	2	0	0	2	N/A
Western Wood-Pewee	0	0	0	2S	2	0	0	2	100.00
Ash-throated Flycatcher	0	1S/1U	0	0	1	0	1	2	100.00
Black-capped Chickadee	1S	0	0	0	1	0	0	1	100.00
Bewick's Wren	0	1S/1U	0	2S	3	0	1	4	100.00
White-breasted Nuthatch	1S	0	0	0	1	0	0	1	100.00
Black-headed Grosbeak	0	0	1F	1U	0	1	1	2	0.00
Lesser Goldfinch	0	0	1S	2S	3	0	0	3	100.00
Totals	18S/4U	10S/6F/4U	4S/4F/2U	22S/5F/3U	55	15	13	83	78.57

* percentage based upon known nest fates.

S = nest success (production of at least one fledgling)
F = nest failure (failure due to predation, weather, abandonment, etc.)
U = unknown (nest fate unknown)

Table 11. Nests Monitored at MRG Middle Fuels Reduction Sites - 2004

	Site				Nest Fates				
Species	MI1	MI2	MI3	MI7	Successful	Failed	Unknown	Total	% Successful *
Cooper's Hawk	1S	1F	0	0	1	1	0	2	50.00
Swainson's Hawk	0	0	1S	0	1	0	0	1	100.00
Mourning Dove	0	3S/10F/2U	1F/1U	6S/4F/5U	9	15	8	32	37.50
Greater Roadrunner	0	0	0	1S	1	0	0	1	100.00
Great Horned Owl	0	0	0	1S	1	0	0	1	100.00
Black-chinned Hummingbird	10S	4S	1S	7S/3F	22	3	0	25	88.00
Downy Woodpecker	2S/1F	2S	1S	1S	6	1	0	7	85.71
Hairy Woodpecker	1S	1U	0	0	1	0	1	2	100.00
Northern Flicker	1S	0	0	1S	2	0	0	2	100.00
American Crow	0	0	1U	0	0	0	1	1	0.00
Black-capped Chickadee	1S	1S	1U	0	2	0	1	3	100.00
Bewick's Wren	1S	0	1S/2U	0	2	0	2	4	100.00
Gray Catbird	0	0	0	1F	0	1	0	1	0.00
European Starling	0	0	0	1S	1	0	0	1	100.00
Yellow-breasted Chat	0	1S	0	0	1	0	0	1	100.00
Spotted Towhee	0	1F	0	0	0	1	0	1	0.00
Summer Tanager	0	1S	1S	0	2	0	0	2	100.00
Blue Grosbeak	1S	2S/1F/1U	0	1S/1U	4	1	2	7	80.00
Lesser Goldfinch	1U	0	1S	0	1	0	1	2	100.00
Totals	18S/1F/1U	14S/13F/4U	6S/1F/5U	19S/8F/6U	57	23	16	96	71.25

* percentage based upon known nest fates.

S = nest success (production of at least one fledgling)
F = nest failure (failed due to predation, weather, abandonment, etc.)
U = unknown (nest fate unknown)

Table 12. Nests Monitored at MRG South Fuels Reduction Sites - 2004

Species	Site: SO1	SO2	SO3	SO4	Nest Fates: Successful	Failed	Unknown	Total	% Successful *
Mallard	0	1F	0	0	0	1	0	1	0.00
Cooper's Hawk	0	1S	0	0	1	0	0	1	100.00
Killdeer	0	0	1U	0	0	0	1	1	N/A
Mourning Dove	1F	2U	2F	1F	0	4	2	6	0.00
Great Horned Owl	0	1S	0	0	1	0	0	1	100.00
Black-chinned Hummingbird	1S/2F/1U	3S/1U	1S/1F	0	5	3	2	10	62.50
Ladder-backed Woodpecker	0	0	1S	0	1	0	0	1	100.00
Downy Woodpecker	1S	0	1S	0	2	0	0	2	100.00
Hairy Woodpecker	0	1S	0	1S	2	0	0	2	100.00
Ash-throated Flycatcher	0	1S/3U	1S/2U	1S	3	0	5	8	100.00
Western Kingbird	0	0	0	1U	0	0	1	1	N/A
Bewick's Wren	0	3S/1U	0	1F	3	1	1	5	75.00
Phainopepla	0	2S/1U	1F	1S/1F	3	2	1	6	60.00
Yellow-breasted Chat	0	1S	0	0	1	0	0	1	100.00
Spotted Towhee	1F	0	1S	0	1	1	0	2	50.00
Summer Tanager	1F	1S	0	2S	3	1	0	4	75.00
Black-headed Grosbeak	1S/3F	1U	0	0	1	3	1	5	25.00
Blue Grosbeak	1F/1U	1S	0	0	1	1	1	3	50.00
House Finch	0	0	1U	1U	0	0	2	2	N/A
Lesser Goldfinch	0	1S	0	0	1	0	0	1	100.00
Totals	3S/9F/2U	16S/1F/9U	5S/4F/4U	5S/3F/2U	29	17	17	63	63.04

* percentage based upon known nest fates.

S = nest success (production of at least one fledgling)
F = nest failure (failure due to predation, weather, abandonment, etc.)
U = unknown (nest fate unknown)

(Table 13). Fewer nests were located in 2004 due to the reduced availability of nesting strata on cleared sites as well as reduced access because of fires and weather.

Two new species, Ring-necked Pheasant and Greater Roadrunner, had nests located for the first time this season, although both have been observed with fledglings on the study sites in previous years. Over the course of the study, 43 species have been found nesting with about 12 additional species either probably nesting on the plots or breeding in adjacent habitats and often found in the bosque.

As in previous years, Black-chinned Hummingbirds were by far the most commonly located nests with 79 found this season. 40 Mourning Dove nests were found making it the 2nd most frequently located species. Both species exhibited the same pattern of success as in previous years with hummingbirds mostly successful (80%) and doves mostly unsuccessful (32%).

With the removal of the exotic understory, there was a shift in the relative numbers of types of nests located. Canopy and cavity guild nests were found more frequently on treated sites than untreated sites (Figure 12). These increases may be related to increased observer access to the plots, improved visibility of the canopy, or increased numbers of nesters after cutting. At the same time, the number of shrub guild nests has declined (Figure 12). Declines may be from the reduced availability of desirable nesting sites and lower numbers of shrub-nesting birds.

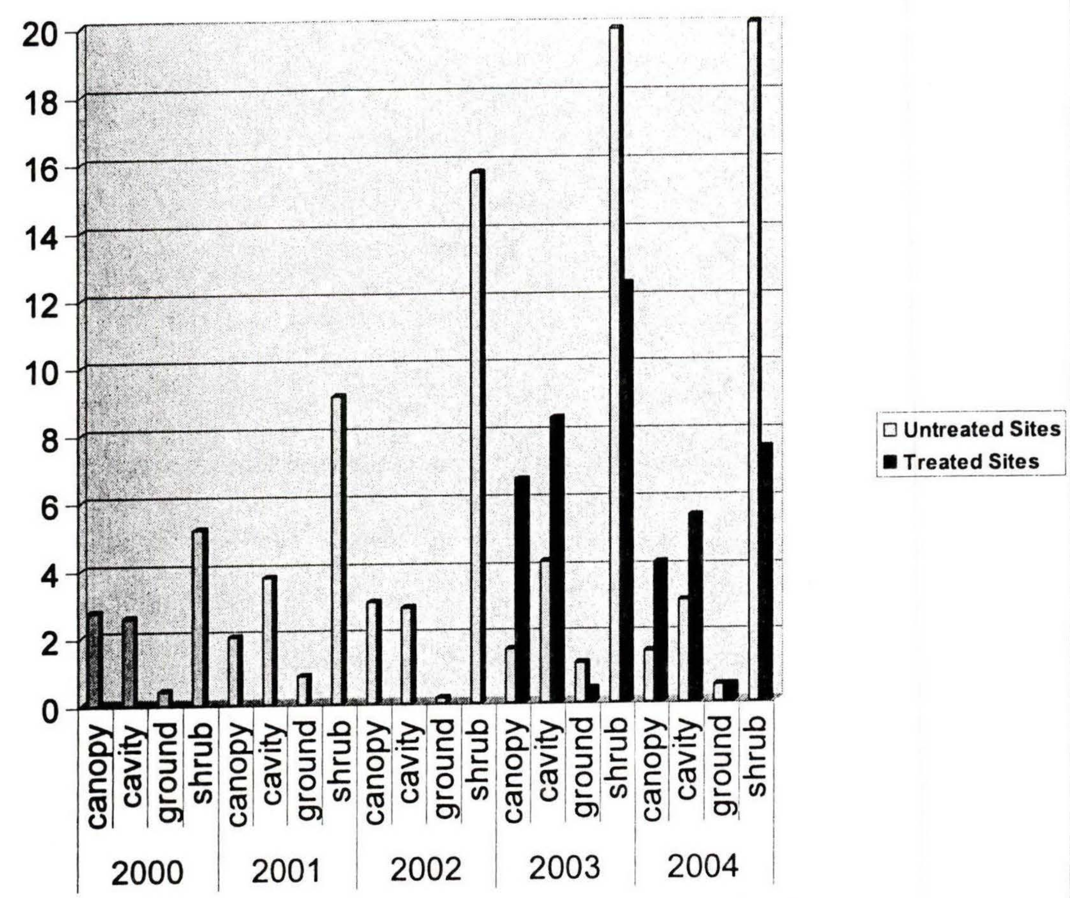
There was a higher rate of nests with unknown fates this year due to several factors. With the removal of much of the understory, we found relatively more canopy nests in 2004 than in previous years. Because these are more difficult to see, it is often harder to determine the outcome of these nests. Fires and bad weather also limited access to some sites at times, leaving some nests unmonitored for relatively long periods of time thus making it difficult to determine outcomes.

As yet, no discernable patterns have emerged to suggest that species are less successful at nesting on treated sites. Overall success rates on treated plots are comparable to pre-treatment sites. If birds can find a suitable location to nest, they have largely been successful at producing young at

Table 13. Total Nests Located by Year (Shaded areas = cut plots)

Site	2000	2001	2002	2003	2004	Total
NO1 (Control)	12	28	34	32	22	128
NO2	14	19	23	**23**	**20**	99
NO3	7	18	13	21	**10**	69
NO4	9	25	32	**50**	**30**	146
MI1	16	14	18	24	**20**	92
MI2	8	13	29	25	31	106
MI3	6	16	17	26	**12**	77
MI4 (Control)	4	10				14
MI7 (Control)			18	40	34	92
SO1 (Control)	9	12	17	19	14	71
SO2	28	22	35	**42**	**26**	153
SO3	9	7	14	**7**	**13**	50
SO4	9	4	10	**17**	**10**	50
Total	131	188	260	326	242	1147

Figure 12. Mean Number of Guild Nests Located per Site by Year



about the same rate. However, there has obviously been a decline in the number of suitable nest sites for shrub nesting birds on treated sites which may result in declining productivity over time.

Illustrating the changes in the landscape brought about by the treatment process was the detection of a pair of Killdeer that nested on the SO-3 plot. A nest with 4 eggs was located on May 11th after adults were seen behaving as if they were nesting on a previous visit. The eggs and adults were gone on the next visit, so it is not known if the nest was successful. Killdeer will only nest in open areas devoid of vegetation (Jackson & Jackson 2000). At the beginning of the study, this nest location was a nearly impenetrable salt cedar thicket that nesting Killdeer would have avoided.

Bat Activity Monitoring Results

Bat activity at each block was monitored one night per week from 7 June to 26 August 2004, resulting in 12 nights of monitoring at each site for the summer. For each night, ultrasonic sounds are recorded and stored in files which contain up to 15s of data. We recorded approx. 36,000 files in the North block during these 12 nights, approx. 21,000 files at the Middle block, and approx. 69,000 files at the South block. Some files do not contain bat calls, but other ultrasonic sounds (insects, background noise, etc.). Thus, the contents of each file must be examined and files not containing bat calls must be removed before bat activity can be quantified at each site. Last fall, we processed all files recorded at Middle block and North block, but were unable to process files from South block due to funding and personnel issues. A person is currently being hired to finish processing call files, and data analysis will proceed once file processing is finished.

Bat roosts were also monitored during the 2004 season. Four new colony roosts were found in 2004 (Figure 18). Three occurred in cottonwood snags (21-64cm DBH), and one occurred in the dead branch of a live cottonwood (69cm DBH). Three of the roosts were located in the SO4 site, and one was located in the SO-2 site. All roosts occurred in crevices under peeling bark, and roosts were occupied for a minimum of 1-2 months. Colonies ranged from 16-61 bats and were likely

composed of female *Myotis occultus* or *M. yumanensis*. The three roosts located in summer 2003 were also in cottonwood snags (31-42cm DBH). Two of these roosts occurred in crevices under bark, and one occurred in a natural cavity. These roosts were empty in summer 2004. Based on roosts found during this Fuels Reduction Study and a previous study (Chung-MacCoubrey 1999), it is apparent that cottonwood snags and live cottonwoods with defects provide important roosting habitat for bats in the bosque. Because most colony roosts occur under bark and the period during which snags lose bark is short, it is important to provide a sufficient number of snags in varying stages of decay. In this study and Chung-MacCoubrey's 1999 study, tree roosts were often located in areas with high densities of cottonwood snags. For example, several roosts were located in snags within cottonwood stands burned by the 1996 fire on the Bosque del Apache National Wildlife Refuge (Chung-MacCoubrey 1999). In this study, most of the tree roosts have been found on the south end of the SO-4 site, where the stand of cottonwoods has been killed by rising water tables. Nonetheless, due to the limited sample size, it is difficult to statistically identify the importance of snag density to roost tree selection.

Herpetofaunal Monitoring Results

In 2004, drift fence arrays were open continuously from 2 June to 17 September (except for the week following 4 July). A total of 2,586 animals were captured at the 12 study sites (Table 15). Twenty-two reptile and amphibian species were represented, including 9 lizard, 4 amphibian, and 9 snake species. One new species, the western diamondback (*Crotalus atrox*) was captured at SO-2. Similar to previous years, three whiptail lizards (New Mexican whiptail - *Cnemidophorus neomexicanus*, Chihuahuan whiptail - *C. exsanguis*, Desert Grassland whiptail - *C. uniparens*), the prairie lizard (*Sceloporus undulatus*) and the Great Plains skink (*Eumeces obsoletus*) were the most frequently captured species. These 5 species occur at all blocks, but in different abundances. Chihuahuan and New Mexico whiptails are caught most frequently in the North block. Prairie

lizards and New Mexico whiptails are caught most frequently in the Middle block. Prairie lizards and Desert Grassland whiptails are caught most frequently in the South block, which also has the greatest species richness. Nearly half of all animals recaptured were lizards (Table 15), and this large number of recaptures should facilitate our future mark-recapture population analysis.

Species richness and composition do not appear to be different in post-treatment years relative to pre-treatment years (Table 14). A preliminary analysis of weekly capture data suggests that capture rates for whiptails and spiny lizards in post-treatment years are not significantly different than capture rates during pre-treatment years (see Figures 13-15). However, statistical tests are yet to be performed, and analyses by individual species or age group may reveal species- or age-related patterns.

Life history information on individual species will also be obtained from our capture data. Weekly plots of capture rates reflect patterns of activity. Adult and hatchling whiptail and spiny lizards have different activity periods during the summer (Rowland and Brattstrom 2001). Adult New Mexico whiptails are most active during June and July, and their activity declines as hatchlings emerge and become active in September (Figure 16). Activity of adult prairie lizards is highest in June, declines during the remainder of the summer, and climbs again in the September when hatchlings emerge (Figure 17). At Middle-1, hatchling spiny lizards were more abundant than in previous years (Figure 15). Data from the upcoming 2005 field season will determine whether the 2004 fall abundance of hatchlings translates into a greater abundance of adults during the summer 2005 season.

Analysis of capture data will also provide information on lifespan of different species. By examining the recapture of uniquely marked individuals across years, we are estimating average, minimum, and maximum life span. We used number of years recaptured to represent minimum lifespan of individuals and assumed that animals never recaptured were dead. Number of years recaptured represented a minimum age because most individuals were already adults when initially

captured. Average lifespan of New Mexico whiptails, Chihuahuan whiptails, and prairie lizards were approximately one year (Table 16). Although maximum documented lifespans of the two whiptail species were similar, we captured more older New Mexico whiptails than Chihuahuan whiptails. Of the New Mexico whiptails, 29 were at least 3 years, 4 were at least 4 years, and 3 were at least 5 years of age. Of the Chihuahuan whiptails, only 8 were at least 3 years, and only 1 was at least 4 years of age. We captured 30 prairie lizards that were at least 3 years old, and 4 that were at least 4 years old.

Natural history information on individual species is needed to interpret how restoration activities will impact populations and communities of herpetofauna. Information from this study on the temporal and spatial activities and habitat requirements of herpetofauna will help biologists predict and mitigate the effects of land management activities.

Table 14. Number and species of reptiles and amphibians captured at the 12 study sites each year.

Taxa	Species	Year 2000	2001	2002	2003	2004
Amphibians	*Ambystoma tigrinum*		2			
	Bufo cognatus	6	5	6	41	**3**
	Bufo spp	1				
	Bufo woodhousii	89	190	293	45	**136**
	Pseudacris triseriata		1			
	Rana catesbiana		2			
	Scaphiopus couchii	1	21	12	6	**22**
	Spea bombifrons	2				
	Spea multiplicata	1	9	1	2	**7**
Lizards	*Cnemidophorus exsanguis*	263	847	428	496	**514**
	Cnemidophorus inornatus			1		
	Cnemidophorus neomexicanus	227	843	681	818	**583**
	Cnemidophorus spp		15		1	
	Cnemidophorus tesselatus		1	9	2	**5**
	Cnemidophorus tigris	7	16	4	2	**1**
	Cnemidophorus uniparens	250	446	180	263	**236**
	Eumeces obsoletus	45	147	91	114	**156**
	Phrynosoma cornutum		1			
	Sceloporus magister		29	18	26	**13**
	Sceloporus undulatus	315	908	809	723	**869**
	Uta stansburiana	3	2	13	17	**7**
Snakes	*Arizona elegans*				1	**1**
	Crotalus atrox					**1**
	Crotalus vividis				1	**6**
	Heterodon nasicus	2	3	1	3	**2**
	Lampropeltis getula	5	11	1	7	**8**
	Leptotyphlops dulcis	1				
	Masticophis flagellum		1	1	1	**2**
	Pituophis melanoleucus	1	5		9	**5**
	Rhinocheilus lecontei		1			
	Tantilla nigriceps	2	3		2	**6**
	Thamnophis elegans	2				
	Thamnophis marcianus		1		3	
	Thamnophis sirtalis	2	5		1	**3**
	Thamnophis spp		3			
Turtles	*Trionyx spinifera*				1	
	Total	1225	3518	2549	2585	**2586**

Table 15. Total number of herpetofauna captured at 12 study sites along the Middle Rio Grande during Summer 2004.

Taxa	Number Captured	Number Recaptured	Percent Recaptured
Lizards	2,384	1,133	47.5%
Amphibians	168	0	0%
Snakes	34	0	0%

Table 16. Lifespan estimates for 3 lizard species (in years). Averages are based on all individuals captured during 2000-2004.

Species	N	Average	StdDev	Range
C. neomexicanus	1579	1.141	0.443	1-5
C. exsanguis	1622	1.055	0.256	1-4
Sceloporus undulatus	1715	1.188	0.449	1-4

Figure 10. Whiptail lizard capture rates by week and year at Middle-1. Pre-treatment years are 2000-03. Post-treatment year is 2004.

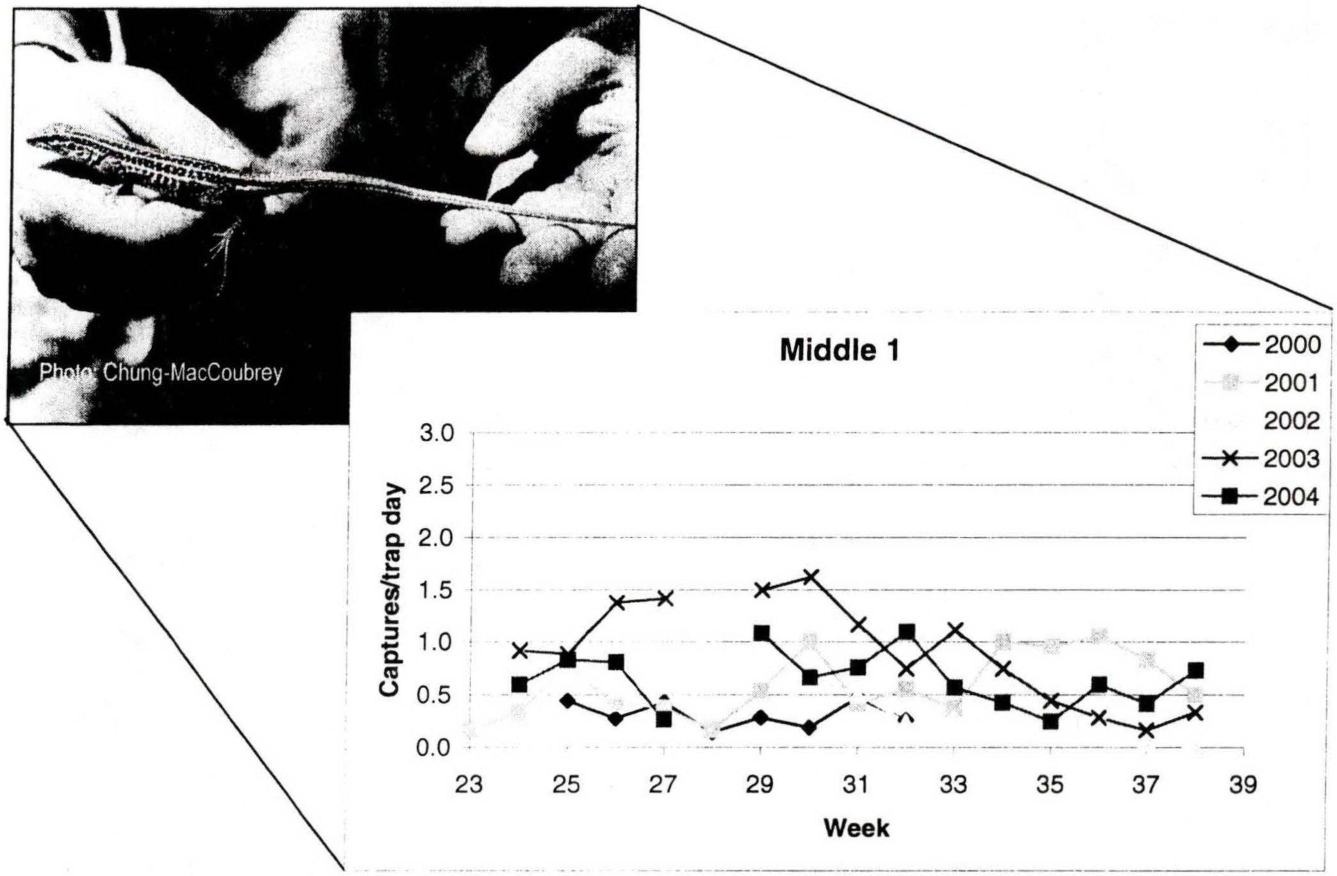


Figure 11. Whiptail lizard capture rates by week and year at South-4. Pre-treatment years are 2000-02. Post-treatment years are 2003-04.

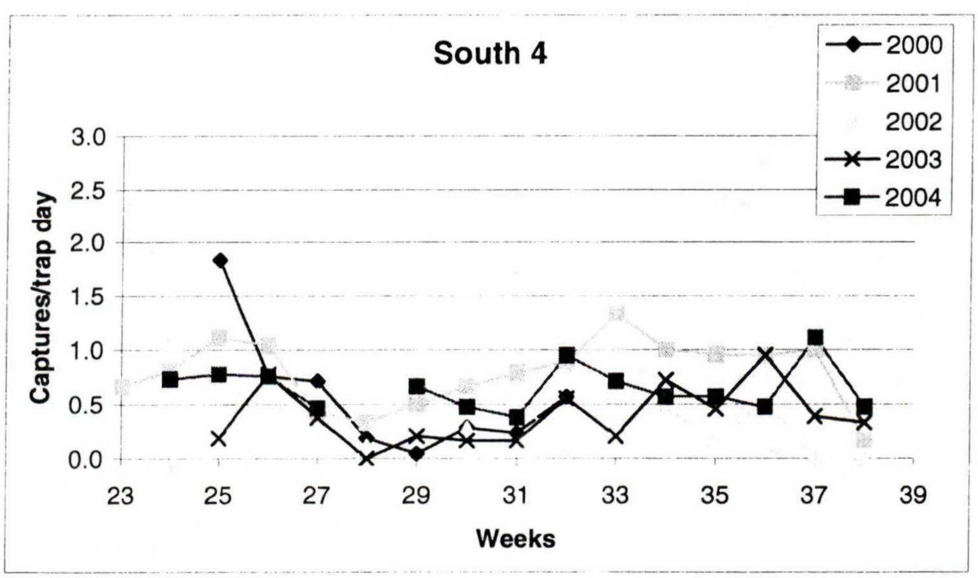


Figure 12. Spiny lizard capture rates by week and day at Middle-1. Pre-treatment years are 2000-03. Post-treatment year is 2004.

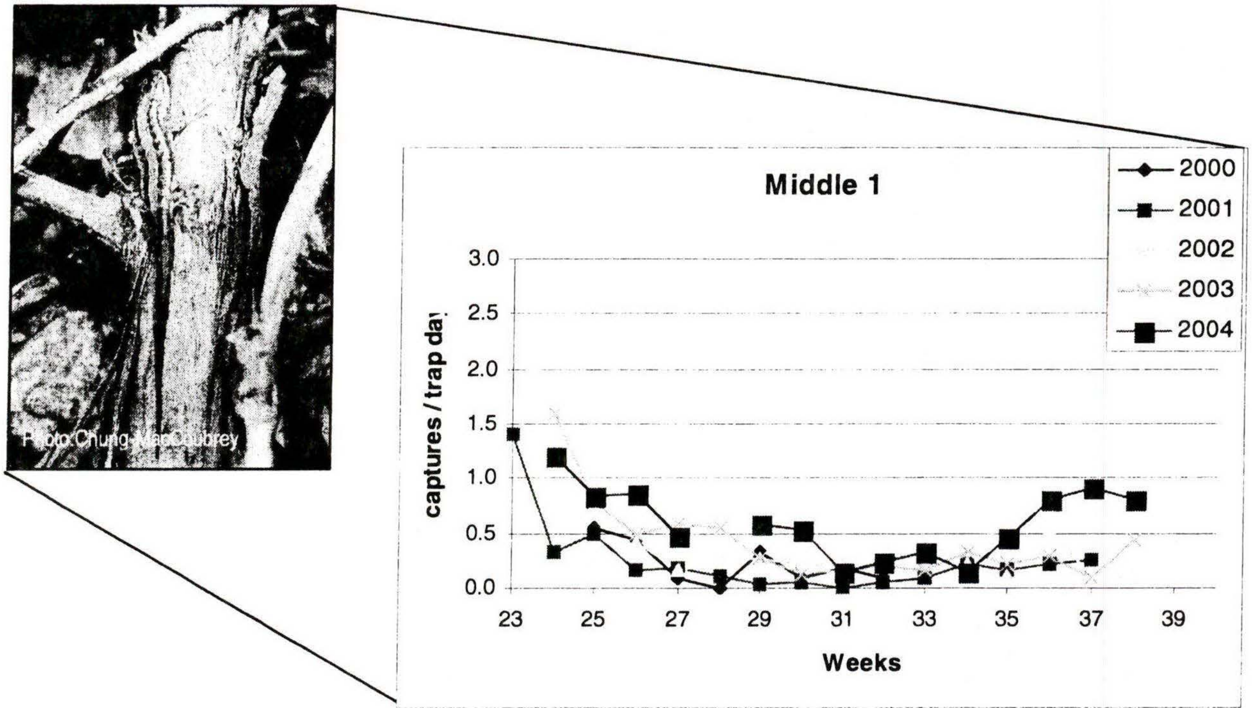


Figure 13. Number of adult and hatchling New Mexico whiptails (*C. neomexicanus*) captured per trap day at Middle-1 in 2004.

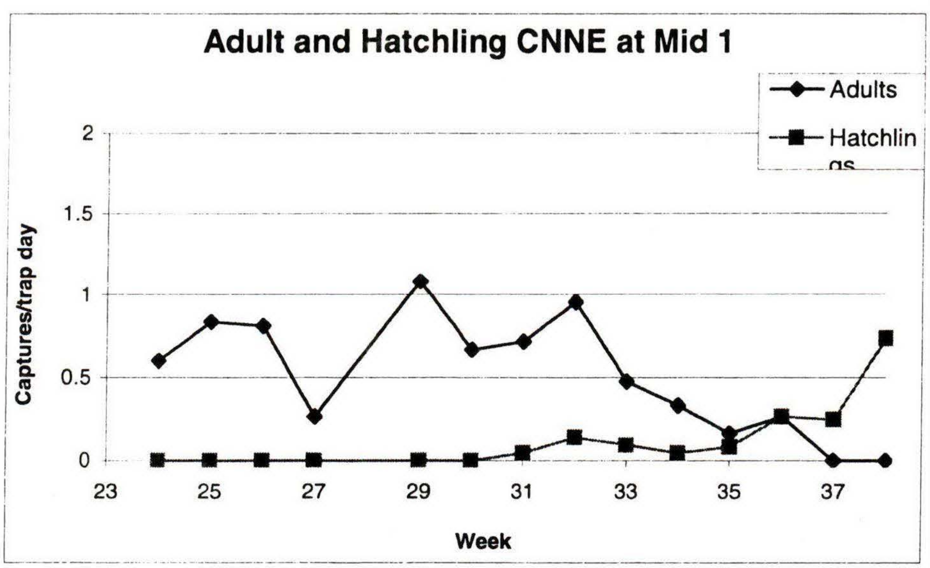


Figure 14. Number of adult and hatchling Eastern fence lizards (*S. undulatus*) captured per trap day at Middle-1 in 2004.

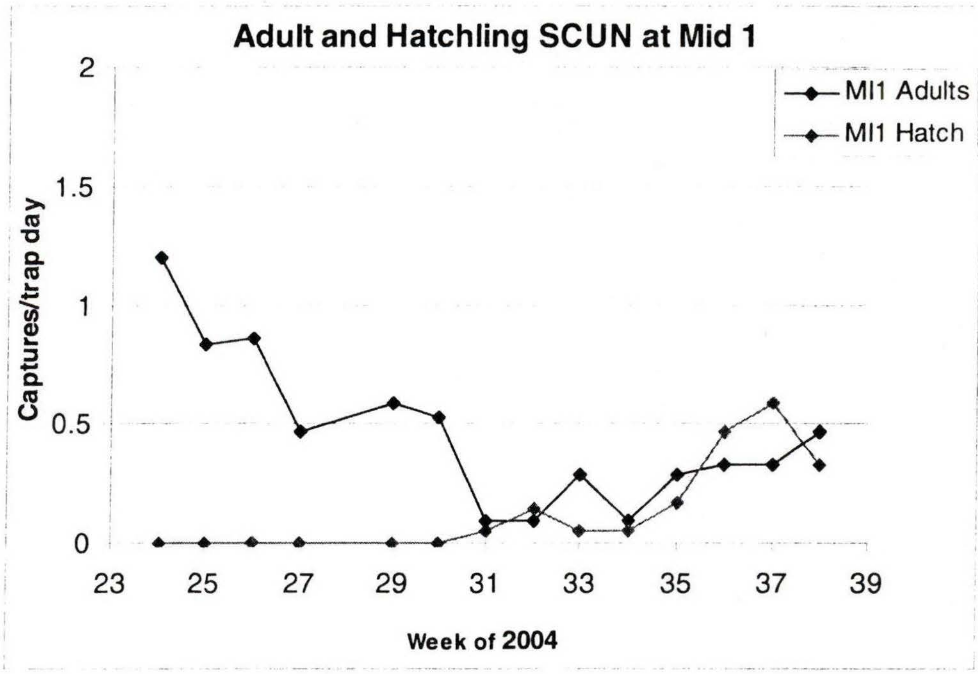
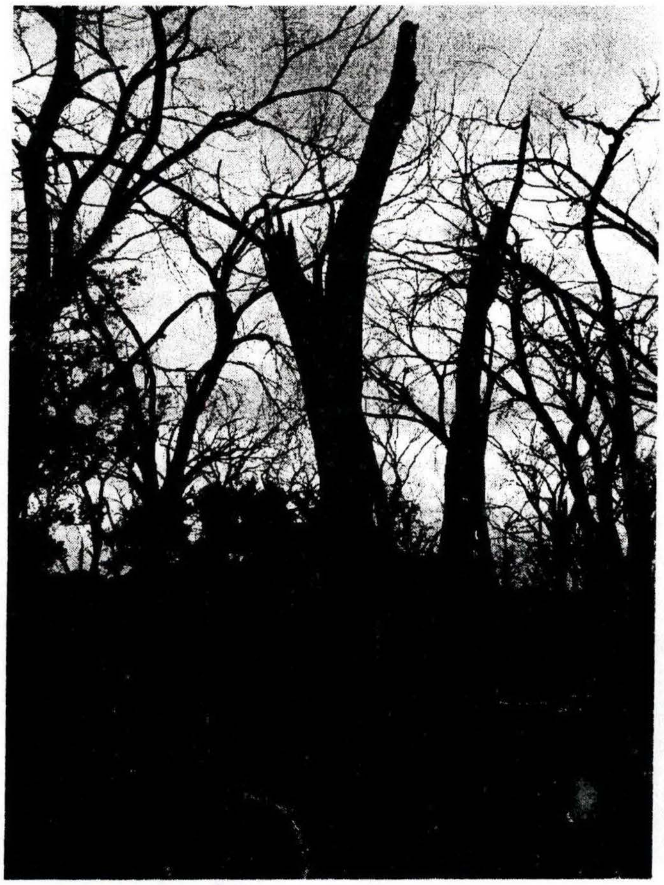


Figure 15. Bat colony roosts frequently occurred under the peeling bark of cottonwood snags in the bosque. These roosts occurred on the Bosque del Apache National Wildlife Refuge.



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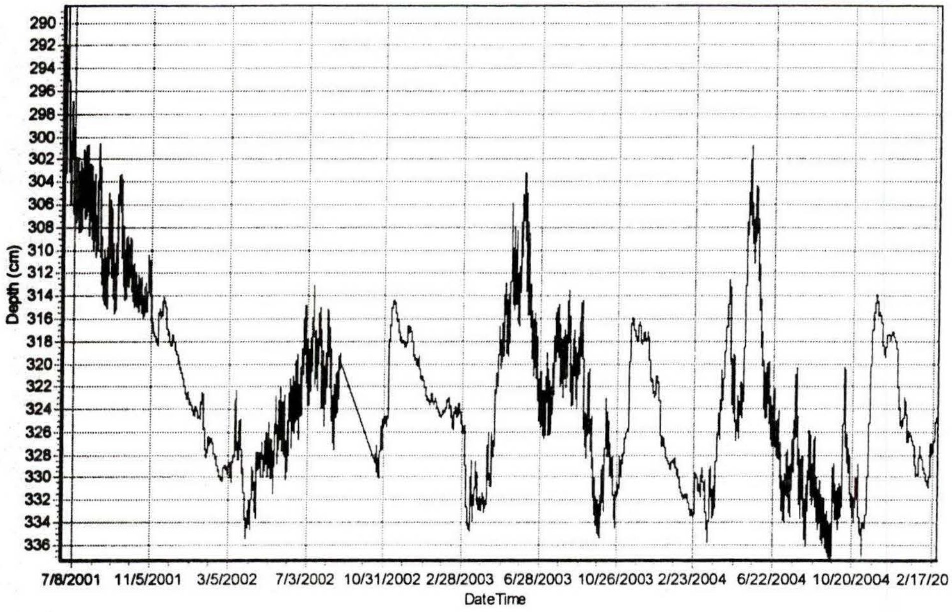
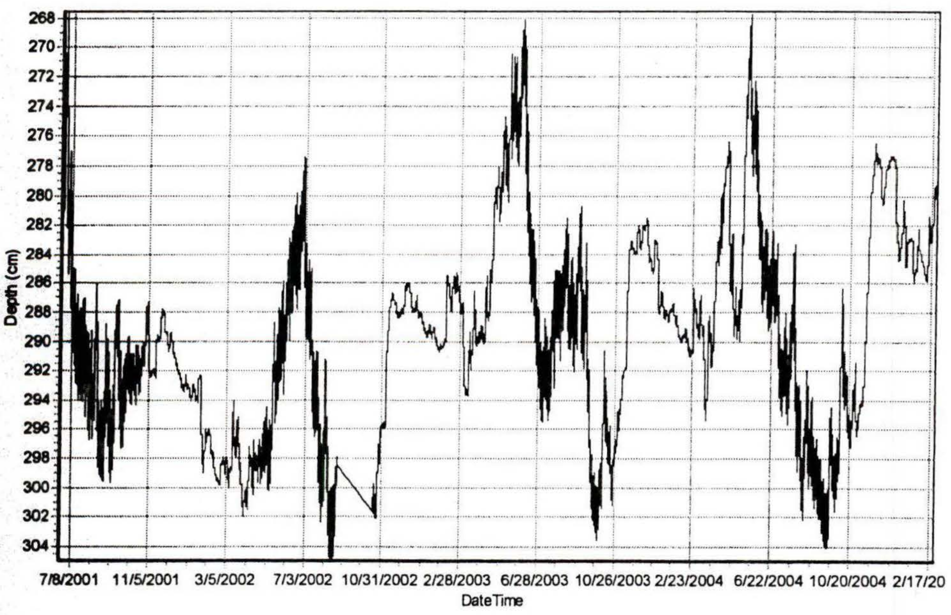
Appendix 1

Preliminary graphs of well logs recorded at the fuels reduction sites. Note that depth to water is from the top of the well casings, which are approximately 80 cm above the ground surface.

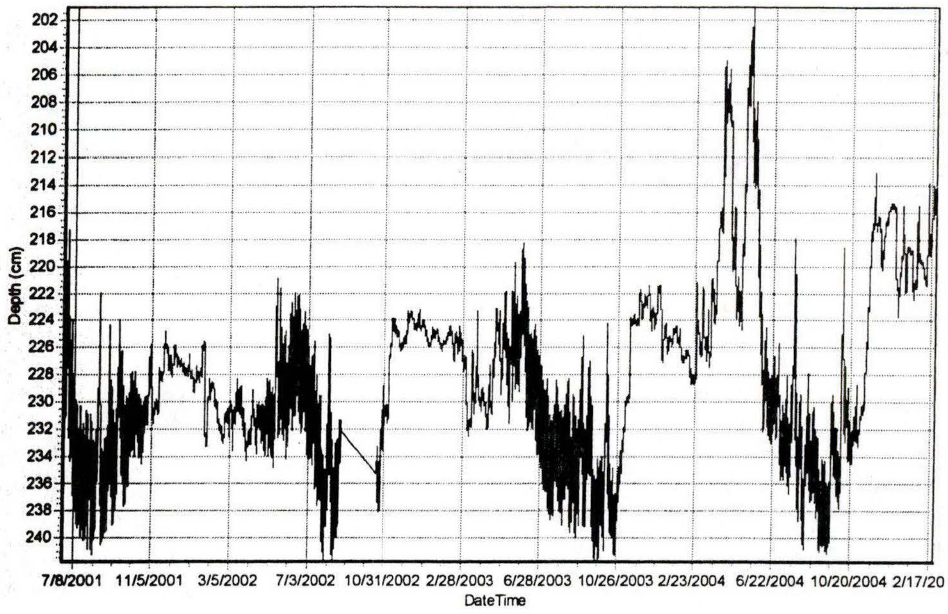
North 1 – 6/21/2002 – 2/24/2005



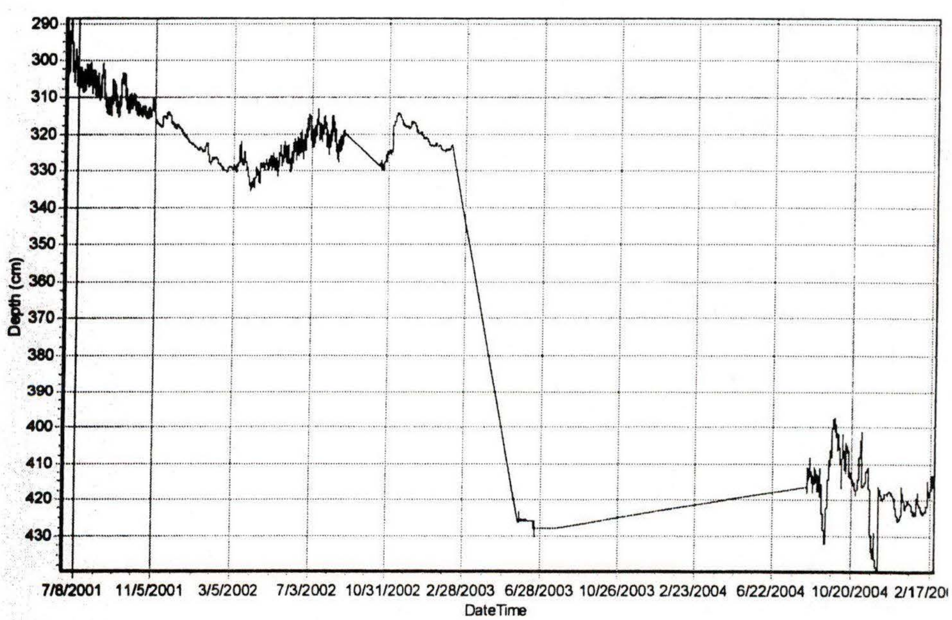
North 2 – 6/21/2001 – 2/24/2005



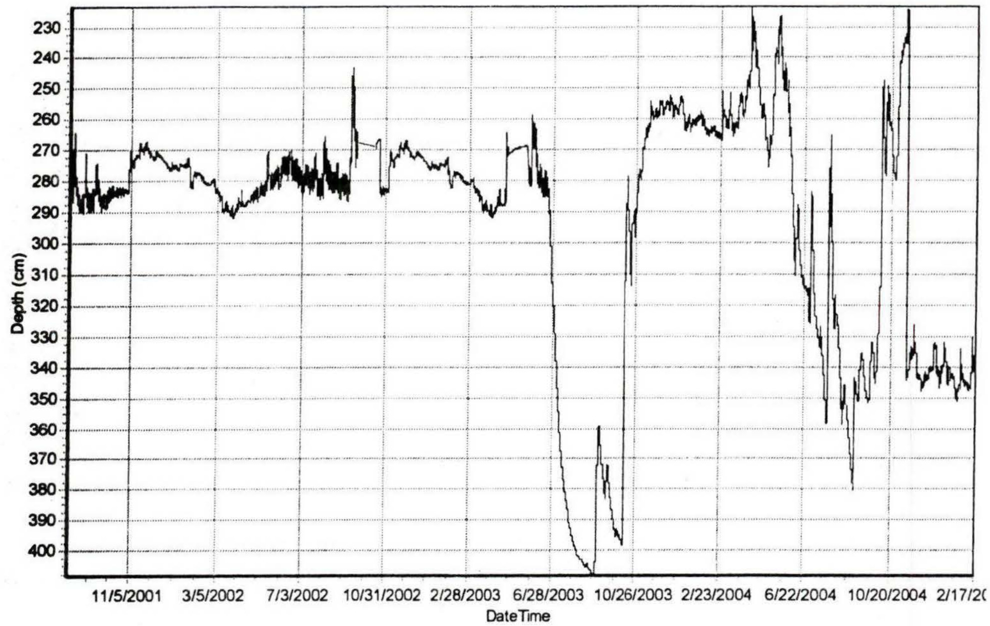
North 3 – 6/21/2001 – 2/24/2005



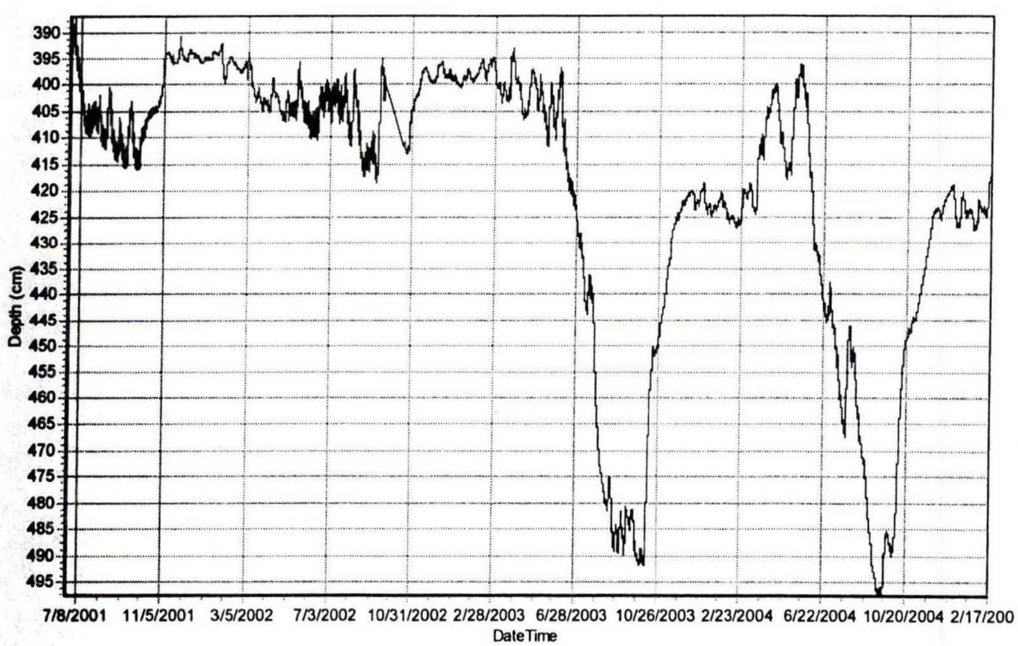
North 4 – 6/21/2001 – 2/24/2005



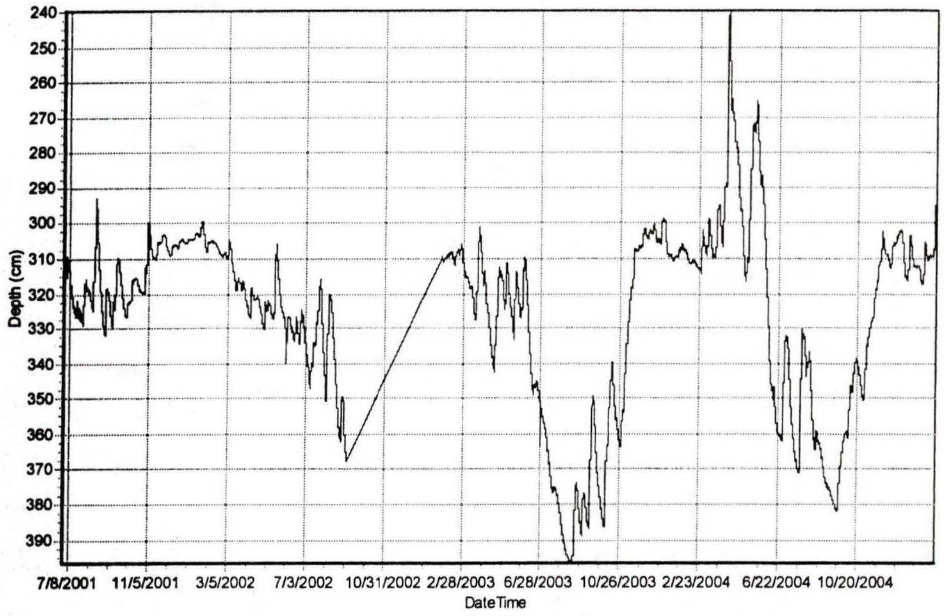
Middle 1 – 8/10/2001 – 2/17/2005



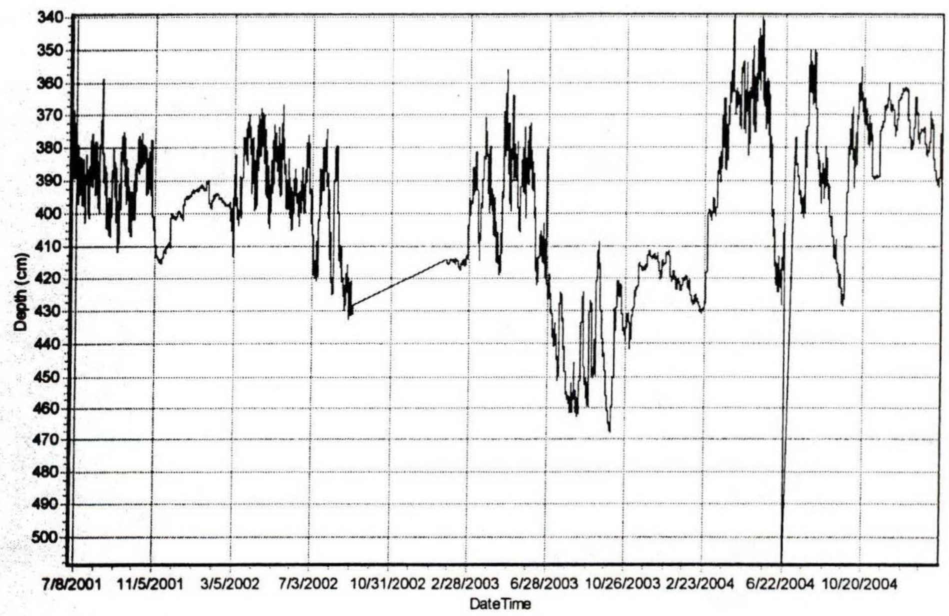
Middle 2 – 6/22/2001 – 2/17/2005



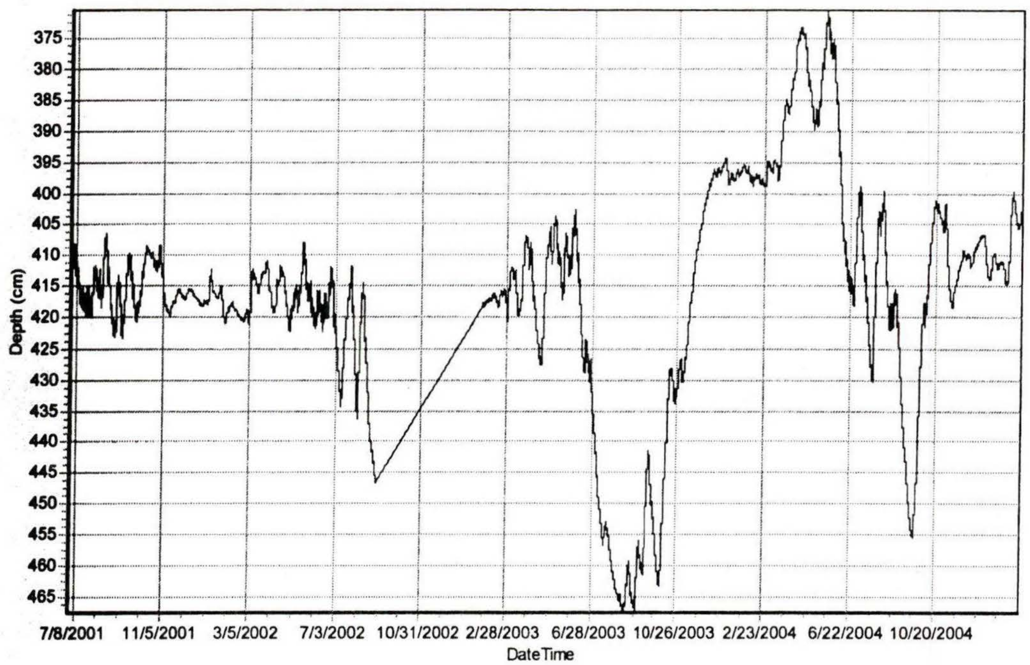
Middle 3 – 6/29/2001 – 2/15/2005



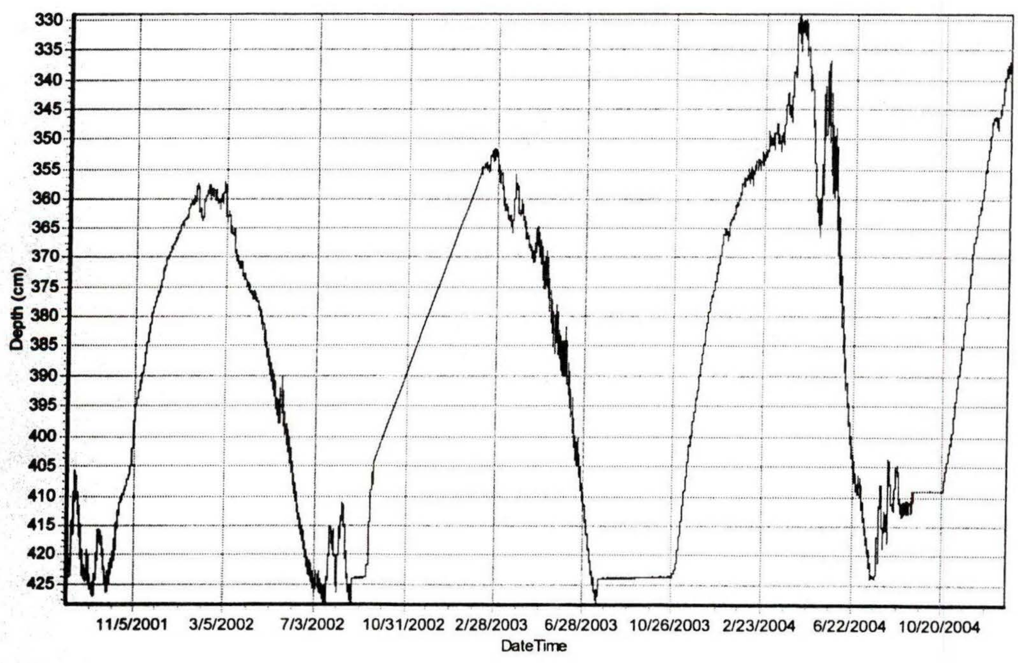
Middle 4 – 6/29/2001 – 2/15/2005



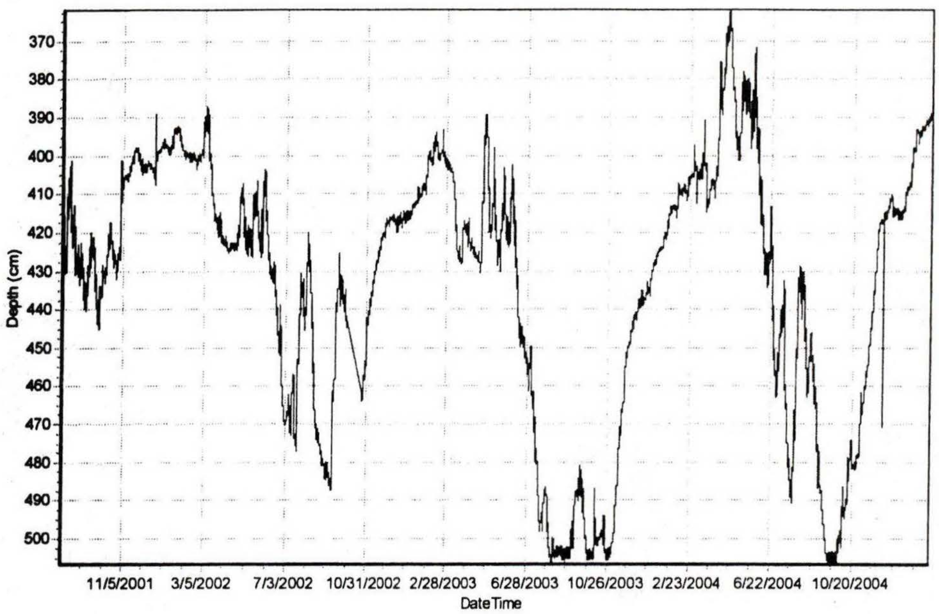
South 1 – 6/28/2001 – 2/15/2005



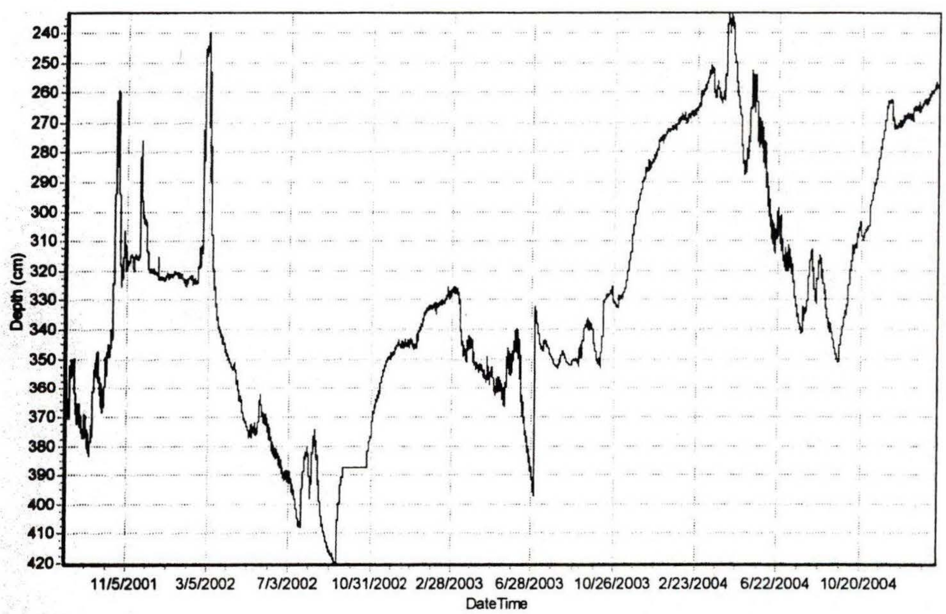
South 2 – 8/7/2001 – 1/13/2005



South 3 – 8/7/2001 – 2/10/2005



South 4 – 8/7/2001 – 2/10/2005



Appendix 2. Plants Recorded on Fuels Reduction Sites

Family	Scientific Name	Common Name	Type	n/e
Aceraceae	Acer negundo	Box elder	tree	native
Amaranthaceae	Amaranthus blitoides	Prostrate pigweed	forb	exotic
Amaranthaceae	Amaranthus hybridus	Pigweed	forb	native
Amaranthaceae	Amaranthus palmeri	Carelessweed	forb	native
Amaranthaceae	Tidestromia lanuginosa	W ooly tidestromia	forb	native
Anacardiaceae	Rhus trilobata	Skunkbush sumac	shrub	native
Apiaceae	Cicuta douglasii	W ater hemlock	forb	native
Apocynaceae	Apocynum androsaemifolium	Spreading dogbane	forb	native
Apocynaceae	Apocynum cannabinum	Indian hemp	forb	native
Araliaceae	Hedera helix	English ivy	forb	exotic
Asclepiadaceae	Asclepias speciosa	Showy milkweed	forb	native
Asclepiadaceae	Asclepias subverticillata	W horled milkweed	forb	native
Asclepiadaceae	Asclepias tuberosa	Butterfly milkweed	forb	native
Asteraceae	Acroptilon repens	Russian knapweed	forb	exotic
Asteraceae	Ambrosia acanthicarpa	Ragweed	forb	native
Asteraceae	Ambrosia psilostachya	W estern ragweed	forb	native
Asteraceae	Arctium minus	Lesser burdock	forb	exotic
Asteraceae	Artemisia campestris	Field sagewort	forb	native
Asteraceae	Artemisia filifolia	Sand sage	shrub	native
Asteraceae	Artemisia ludoviciana	Louisiana sagewort	forb	native
Asteraceae	Aster ericoides	W hite heath aster	forb	native
Asteraceae	Aster falcatus var. commutatus	Heath aster	forb	native
Asteraceae	Baccharis salicifolia	Seepwillow	shrub	native
Asteraceae	Baccharis salicina	Rio Grande seepwillow	shrub	native
Asteraceae	Baileya multiradiata	Desert marigold	forb	native
Asteraceae	Bidens cernua	Bur marigold	forb	exotic
Asteraceae	Chloracantha spinosa	Mexican devilweed	forb	native
Asteraceae	Chrysothamnus linifolius	Chamisa	shrub	native
Asteraceae	Cirsium spp.	Thistle	forb	
Asteraceae	Conyza canadensis	Canadian horseweed	forb	native
Asteraceae	Erigeron divergens	Spreading fleabane	forb	native
Asteraceae	Erigeron flagellaris	Trailing fleabane	forb	native
Asteraceae	Flaveria campestris	Alkali yellowtops	forb	native
Asteraceae	Gaillardia pinnatifida	Yellow blanketflower	forb	native
Asteraceae	Gnaphalium stramineum	Cottonbatting cudweed	forb	native
Asteraceae	Grindelia nuda	Curlytop gumweed	forb	native
Asteraceae	Grindelia squarrosa	Curlycup gumweed	forb	native
Asteraceae	Gutierrezia sarothrae	Broom snakeweed	shrub	native
Asteraceae	Helianthus annuus	Annual sunflower	forb	native
Asteraceae	Helianthus ciliaris	Texas blueweed	forb	native
Asteraceae	Helianthus maximiliani	Maximilian sunflower	forb	native
Asteraceae	Helianthus petiolaris	Prairie sunflower	forb	native
Asteraceae	Heliomeris multiflora	Showy goldeneye	forb	native
Asteraceae	Heterotheca villosa	Hairy golden aster	forb	native
Asteraceae	Hymenopappus filifolius	W hite ragweed	forb	native
Asteraceae	Lactuca serriola	Prickly lettuce	forb	native
Asteraceae	Lactuca tartarica	Blue lettuce	forb	native
Asteraceae	Machaeranthera canescens	Purple aster	forb	native
Asteraceae	Machaeranthera pinnatifida ssp. pinnatifida	Lacy tansyaster	forb	native
Asteraceae	Machaeranthera tanacetifolia	Small-flowered aster	forb	native
Asteraceae	Melampodium leucanthum	Blackfoot	forb	native
Asteraceae	Palafoxia sphacelata	Palafoxia	forb	native
Asteraceae	Ratibida tagetes	Short-rayed coneflower	forb	native
Asteraceae	Scorzonera laciniata	Sivinsky's skorzonera	forb	exotic
Asteraceae	Senecio flaccidus	Douglas groundsel	forb	native
Asteraceae	Senecio riddellii	Riddell's groundsel	forb	native
Asteraceae	Senecio spartoides var. multicapitatus	Many-headed groundsel	forb	native
Asteraceae	Solidago canadensis	Canada goldenrod	forb	native
Asteraceae	Solidago simplex	Narrow goldenrod	forb	native
Asteraceae	Sonchus asper	Spiny sowthistle	forb	exotic
Asteraceae	Taraxacum officinale	Common dandelion	forb	native
Asteraceae	Thelesperma longipes	Longstalk greenthread	forb	native
Asteraceae	Thelesperma megapotamicum	Greenthread	forb	native
Asteraceae	Verbesina encelioides	Cowpen daisy	forb	native
Asteraceae	Viguera cordifolia	Rough goldeneye	forb	native
Asteraceae	Xanthium strumarium	Rough cocklebur	forb	native

Family	Scientific Name	Common Name	Type	n/e
Bignoniaceae	Cryptantha cinerea	Bow-nut cryptantha	forb	native
Boraginaceae	Cryptantha crassisepela	Hiddenflower	forb	native
Boraginaceae	Heliotrope curassavicum	Salt heliotrope	forb	native
Boraginaceae	Lappula occidentalis	Stickseed	forb	native
Brassicaceae	Cardaria draba	Hoary cress	forb	exotic
Brassicaceae	Descurainia sophia	Flixweed	forb	exotic
Brassicaceae	Dimorphocarpa wislizeni	Spectacle pod	forb	native
Brassicaceae	Lepidium latifolium	Perennial pepperweed	forb	exotic
Brassicaceae	Sisymbrium irio	London rocket	forb	native
Cactaceae	Opuntia phaeacantha	Plains prickly pear	shrub	native
Capparaceae	Polanisia dodendra	Sandyseed clammyweed	forb	native
Chenopodiaceae	Atriplex canescens	Four-wing salt bush	shrub	native
Chenopodiaceae	Chenopodium album	Lambquarters	forb	native
Chenopodiaceae	Chenopodium incanum	Mealy goosefoot	forb	native
Chenopodiaceae	Chenopodium leptopyllum	Narrowleaf goosefoot	forb	native
Chenopodiaceae	Kochia scoparia	Summer cypress	forb	exotic
Chenopodiaceae	Salsola kali	Thumbleweed	forb	exotic
Convolvulaceae	Convolvulus arvensis	Bindweed	forb	exotic
Cucurbitaceae	Cucurbita foetidissima	Buffalo gourd	forb	native
Cupressaceae	Juniperus monosperma	Oneseed juniper	tree	native
Cyperaceae	Carex aquatilis	Water sedge	sedge	native
Cyperaceae	Carex praegracilis	Clustered field sedge	sedge	native
Cyperaceae	Cyperus escuelentes	Flatsedge	sedge	native
Cyperaceae	Eleocharis palustris	Common spikerush	rush	native
Cyperaceae	Schoenoplectus americanus	Three square	sedge	native
Cyperaceae	Scirpus acutus	Hardstem bulrush	rush	native
Elaeagnaceae	Elaeagnus angustifolia	Russian olive	tree	exotic
Equisetaceae	Equisetum laevigatum	Smooth horsetail	forb	native
Euphorbiaceae	Chamaesyce fendleri	Fendler's sandmat	forb	native
Euphorbiaceae	Chamaesyce glyptosperma	Ribseed sandmat	forb	native
Euphorbiaceae	Chamaesyce maculata	Spotted spurge	forb	native
Euphorbiaceae	Chamaesyce serpens	Matted sandmat	forb	native
Euphorbiaceae	Chamaesyce serpylliflora	Thymeleaf sandmat	forb	native
Euphorbiaceae	Chamaesyce serrula	Sawtooth sandmat	forb	native
Euphorbiaceae	Croton texensis	Texas croton	forb	native
Euphorbiaceae	Euphorbia spp.	Spurge	forb	native
Euphorbiaceae	Reverchonia arenaria	Dune reverchon	forb	native
Fabaceae	Amorpha fruticosa	Indigo bush	shrub	native
Fabaceae	Astragalus amphioxys	Crescent milkvetch	forb	native
Fabaceae	Dalea candida	White prairie clover	forb	native
Fabaceae	Dalea lanata	Woolly prairieclover	forb	native
Fabaceae	Gleditsia triacanthos	Honey locust	tree	exotic
Fabaceae	Glycyrrhiza lepidota	Wild licorice	forb	native
Fabaceae	Hoffmannseggia glauca	Hog potato	forb	native
Fabaceae	Medicago sativa	Alfalfa	forb	exotic
Fabaceae	Melilotus albus	White sweet clover	forb	exotic
Fabaceae	Melilotus officinale	Yellow sweet clover	forb	exotic
Fabaceae	Psoralidium tenuiflorum	Scurf pea	forb	native
Fabaceae	Sphaerophysa salsula	Red bladderpod	forb	native
Fabaceae	Trifolium repens	White clover	forb	exotic
Gentianaceae	Centaurium calycosum	Arizona centaury	forb	native
Geraniaceae	Erodium cicutarium	Redstem stork's bill	forb	exotic
Geraniaceae	Geranium richardsonii	Richardson's geranium	forb	native
Grossulariaceae	Ribes aureum	Golden currant	shrub	native
Hydrophyllaceae	Nama hispidum	Purple mat	forb	native
Juncaceae	Juncus mexicanus	Wire rush	rush	native
Juncaceae	Juncus torreyi	Torrey's rush	rush	native
Lamiaceae	Hedeoma drummondii	False pennyroyal	forb	native
Lamiaceae	Marrubium vulgare	Horehound	forb	exotic
Lamiaceae	Nepeta cataria	Catnip	forb	exotic
Lamiaceae	Salvia reflexa	Lance-leaved sage	forb	native
Liliaceae	Asparagus officinale	Asparagus	forb	exotic
Loasaceae	Mentzelia multiflora	Blazing star	forb	native
Malvaceae	Anoda cristata	Spurred anoda	forb	exotic
Malvaceae	Malva neglecta	Cheesewood	forb	exotic
Malvaceae	Sphaeralcea ambigua	Desert hollyhock	forb	native
Malvaceae	Sphaeralcea angustifolia	Narrowleaf globemallow	forb	native
Malvaceae	Sphaeralcea fendleri	Fendler's globemallow	forb	native

Family	Scientific Name	Common Name	Type	n/e
Mimosaceae	Desmanthus illionoensis	Prairie bundleflower	forb	native
Mimosaceae	Prosopsis glandulosa	Honey mesquite	tree	native
Mimosaceae	Prosopsis pubescens	Screwbean mesquite	tree	native
Moraceae	Morus alba	White mulberry	tree	exotic
Nyctaginaceae	Mirabilis glabra	Desert four-o'clock	forb	native
Oleaceae	Forestiera pubescens	New Mexico olive	shrub	native
Oleaceae	Fraxinus velutina	Velvet ash	tree	native
Onagraceae	Gaura parviflora	Small-flowered gaura	forb	native
Onagraceae	Oenothera caespitosa	Stemless evening primrose	forb	native
Onagraceae	Oenothera coronopifolia	Pink evening primrose	forb	native
Onagraceae	Oenothera elata	Hooker's evening primerose	forb	native
Onagraceae	Oenothera macrocarpa	Missouri evening primrose	forb	native
Plantaginaceae	Plantago major	Common Plantain	forb	exotic
Poaceae	Agropyron smithii	Western wheatgrass	grass	native
Poaceae	Agrostis gigantea	Redtop	grass	exotic
Poaceae	Aristida purpurea var. purpurea	Purple three-awn	grass	native
Poaceae	Bothriochloa laguroides	Silver bluestem	grass	native
Poaceae	Bouteloua barbata	Six-weeks grama	grass	native
Poaceae	Bouteloua curtipendula	Sideoats grama	grass	native
Poaceae	Bouteloua hirsuta	Hairy grama	grass	native
Poaceae	Bromus japonicus	Japanese brome	grass	exotic
Poaceae	Bromus tectorum	Cheatgrass	grass	exotic
Poaceae	Chloris virgata	Feather fingergrass	grass	native
Poaceae	Cynodon dactylon	Bermuda grass	grass	exotic
Poaceae	Distichlis spicata	Saltgrass	grass	native
Poaceae	Echinochloa crus-galli	Barnyard grass	grass	exotic
Poaceae	Elymus canadensis	Canadian wildrye	grass	native
Poaceae	Elymus elymoides	Squirreltail bottlebrush	grass	native
Poaceae	Elymus glaucus	Blue wildrye	grass	native
Poaceae	Elymus trachycaulus	Slender wheatgrass	grass	native
Poaceae	Elytrigia elongata	Tall wheatgrass	grass	exotic
Poaceae	Elytrigia intermedia	Intermediate wheatgrass	grass	exotic
Poaceae	Hordeum jubatum	Foxtail barley	grass	native
Poaceae	Lolium perrene	Italian ryegrass	grass	exotic
Poaceae	Lycurus phleoides	Wolftail	grass	native
Poaceae	Muhlenbergia asperifolia	Alkali muhly	grass	native
Poaceae	Oryzopsis hymenoides	Indian rice grass	grass	native
Poaceae	Panicum capillare	Witch grass	grass	native
Poaceae	Panicum obtusum	Vine-mesquite	grass	native
Poaceae	Panicum virgatum	Switchgrass	grass	native
Poaceae	Phragmites australis	Common reed	grass	native
Poaceae	Poa palustris	Fowl bluegrass	grass	native
Poaceae	Poa pratensis	Kentucky bluegrass	grass	native
Poaceae	Polypogon monspeliensis	Rabbitsfoot grass	grass	exotic
Poaceae	Pseudoroegneria spicata	Beardless wheatgrass	grass	native
Poaceae	Setaria viridis	Green bristlegram	grass	exotic
Poaceae	Sorghum halepense	Johnson grass	grass	exotic
Poaceae	Sporobolus airoides	Alkali sacaton	grass	native
Poaceae	Sporobolus contractus	Spike dropseed	grass	native
Poaceae	Sporobolus cryptandrus	Sand dropseed	grass	native
Poaceae	Sporobolus flexuosus	Mesa dropseed	grass	native
Poaceae	Sporobolus giganteus	Giant dropseed	grass	native
Poaceae	Sporobolus wrightii	Giant sacaton	grass	native
Poaceae	Stipa comata	Needle-and-thread	grass	native
Poaceae	Vulpia octoflora	Six-weeks fescue	grass	native
Poaceae	X Elyhordeum macounii	Macoun wildrye cross	grass	native
Polemoniaceae	Ipomopsis longiflora	Trumpet gilia	forb	native
Polygonaceae	Rumex crispus	Curley dock	forb	exotic
Portulacaceae	Portulaca oleracea	New Mexico purslane	forb	native
Ranunculaceae	Clemantis drummondi	Drummond's clemantis	forb	native
Ranunculaceae	Ranunculus aquatilis	Water crowfoot	forb	native
Rosaceae	Argentina anserina	Silverweed cinquefoil	forb	native
Salicaceae	Populus deltoides ssp. wislizeni	Rio Grande cottonwood	tree	native
Salicaceae	Salix amygdaloides	Peachleaf willow	shrub	native
Salicaceae	Salix exigua	Coyote willow	shrub	native
Salicaceae	Salix gooddingii	Goodding's willow	tree	native

Family	Scientific Name	Common Name	Type	n/e
Saururaceae	Anemopsis californica	Yerba mansa	forb	native
Scrophulariaceae	Epixiphium wislizenii	Giant snapdragon vine	forb	native
Scrophulariaceae	Penstemon ambiguus	Sand penstemon	forb	native
Scrophulariaceae	Verbascum thapsus	Common mullein	forb	exotic
Simaroubaceae	Ailanthus altissima	Tree of heaven	tree	exotic
Solanaceae	Datura ferox	Oak-leaved thornapple	forb	exotic
Solanaceae	Datura wrightii	Jimsonweed	forb	native
Solanaceae	Lycium pallidum	Pale wolfberry	shrub	native
Solanaceae	Physalis hederaefolia	Ivy-leaved groundcherry	forb	native
Solanaceae	Physalis virginiana	Virginia groundcherry	forb	native
Solanaceae	Solanum americanum	American black nightshade	shrub	native
Solanaceae	Solanum douglasii	Arizona nightshade	forb	native
Solanaceae	Solanum elaeagnifolium	Silverleaf nightshade	forb	native
Solanaceae	Solanum jamesii	Wild potato	forb	native
Solanaceae	Solanum triflorum	Cutleaf nightshade	forb	native
Tamaricaceae	Tamarix ramosissima	Tamarisk	tree	exotic
Typhaceae	Typha angustifolia	Narrow-leaved cattail	rush	native
Ulmaceae	Celtis occidentalis	Common hackberry	tree	native
Ulmaceae	Ulmus pumila	Siberian elm	tree	exotic
Verbenaceae	Verbena bracteata	Weed verbena	forb	native
Vitaceae	Parthenocissus quinquefolia	Virgina creeper	shrub	native
Zygophyllaceae	Kallstroemia parviflora	Warty carpetweed	forb	native
Zygophyllaceae	Tribulus terrestris	Goathead	forb	exotic

Appendix 3. Birds Detected on Point Count Surveys, 2000-2004

Common Name	Scientific Name
Waterfowl	**Anatidae**
Canada Goose	Branta canadensis
Wood Duck	Aix sponsa
Gadwall	Anas strepera
Mallard	Anas platyrhynchos
Northern Shoveler	Anas clypeata
Northern Pintail	Anas acuta
Green-winged Teal	Anas crecca
Pheasant and Turkey	**Phasianidae**
Ring-necked Pheasant	Phasianus colchicus
Wild Turkey	Meleagris gallopavo
Quail	**Odontophoridae**
Gambel's Quail	Callipepla gambelii
Grebes	**Podicipedidae**
Pied-billed Grebe	Podilymbus podiceps
Pelicans	**Pelecanidae**
American White Pelican	Pelecanus erythrorhynchos
Cormorants	**Phalacrocoracidae**
Neotropic Cormorant	Phalacrocorax brasilianus
Double-crested Cormorant	Phalacrocorax auritus
Herons, and Egrets	**Ardeidae**
Great Blue Heron	Ardea herodias
Great Egret	Ardea alba
Snowy Egret	Egretta thula
Cattle Egret	Bubulcus ibis
Green Heron	Butorides virescens
Black-crowned Night-Heron	Nycticorax nycticorax
Ibises	**Threskiornithidae**
White-faced Ibis	Plegadis chihi
Vultures	**Cathartidae**
Turkey Vulture	Cathartes aura
Osprey, Kites and Hawks	**Accipitridae**
Osprey	Pandion haliaetus
Mississippi Kite	Ictinia mississippiensis
Cooper's Hawk	Accipiter cooperii
Swainson's Hawk	Buteo swainsonii
Red-tailed Hawk	Buteo jamaicensis
Ferruginous Hawk	Buteo regalis
Falcons	**Falconidae**
American Kestrel	Falco sparverius
Rails and Coots	**Rallidae**
Common Moorhen	Gallinula chloropus
American Coot	Fulica americana
Plovers	**Charadriidae**
Killdeer	Charadrius vociferus
Stilt and Avocet	**Recurvirostridae**
Black-necked Stilt	Himantopus mexicanus
American Avocet	Recurvirostra americana
Sandpipers	**Scolopacidae**
Greater Yellowlegs	Tringa melanoleuca
Spotted Sandpiper	Actitis macularius
Long-billed Curlew	Numenius americanus
Wilson's Snipe	Gallinago delicata

Common Name	Scientific Name
Gulls	**Laridae**
Ring-billed Gull	Larus delawarensis
Pigeons and Doves	**Columbidae**
Rock Pigeon	Columba livia
White-winged Dove	Zenaida asiatica
Mourning Dove	Zenaida macroura
Cuckoos and Roadrunner	**Cuculidae**
Yellow-billed Cuckoo	Coccyzus americanus
Greater Roadrunner	Geococcyx californicus
Typical Owls	**Strigidae**
Western Screech-Owl	Megascops kennicotti
Great Horned Owl	Bubo virginianus
Nighthawks	**Caprimulgidae**
Lesser Nighthawk	Chordeiles acutipennis
Common Nighthawk	Chordeiles minor
Hummingbirds	**Trochilidae**
Black-chinned Hummingbird	Archilochus alexandrinus
Broad-tailed Hummingbird	Selasphorus platycercus
Rufous Hummingbird	Selasphorus rufus
Kingfishers	**Alcedinidae**
Belted Kingfisher	Ceryle alcyon
Woodpeckers	**Picidae**
Lewis's Woodpecker	Melanerpes lewis
Ladder-backed Woodpecker	Picoides scalaris
Downy Woodpecker	Picoides pubescens
Hairy Woodpecker	Picoides villosus
Northern Flicker	Colaptes auratus
Flycatchers	**Tyrannidae**
Olive-sided Flycatcher	Contopus cooperi
Western Wood-Pewee	Contopus sordidulus
Willow Flycatcher	Empidonax traillii
Dusky Flycatcher	Empidonax oberholseri
Cordilleran Flycatcher	Empidonax occidentalis
Black Phoebe	Sayornis nigricans
Say's Phoebe	Sayornis saya
Ash-throated Flycatcher	Myiarchus cinerascens
Western Kingbird	Tyrannus verticalis
Vireos	**Vireonidae**
White-eyed Vireo	Vireo griseus
Plumbeous Vireo	Vireo plumbeus
Cassin's Vireo	Vireo cassinii
Warbling Vireo	Vireo gilvus
Jays, Magpies, Crows and Ravens	**Corvidae**
Western Scrub-Jay	Aphelocoma californica
Pinyon Jay	Gymnorhinus cyanocephalus
Black-billed Magpie	Pica hudsonia
American Crow	Corvus brachyrhynchos
Chihuahuan Raven	Corvus cryptoleucus
Common Raven	Corvus corax
Swallows	**Hirundinidae**
Violet-green Swallow	Tachycineta thalassina
Northern Rough-winged Swallow	Stelgidopteryx serripennis
Bank Swallow	Riparia riparia
Cliff Swallow	Petrochelidon pyrrhonota
Barn Swallow	Hirundo rustica

Common Name	Scientific Name
Chickadees	**Paridae**
Black-capped Chickadee	Poecile atricapillus
Mountain Chickadee	Poecile gambeli
Verdin	**Remizidae**
Verdin	Auriparus flaviceps
Bushtit	**Aegithalidae**
Bushtit	Psaltriparus minimus
Nuthatches	**Sittidae**
White-breasted Nuthatch	Sitta carolinensis
Creeper	**Certhiidae**
Brown Creeper	Certhia americana
Wrens	**Troglodytidae**
Bewick's Wren	Thryomanes bewickii
House Wren	Troglodytes aedon
Marsh Wren	Cistothorus palustris
Kinglets	**Regulidae**
Ruby-crowned Kinglet	Regulus calendula
Gnatcatchers	**Sylviidae**
Blue-gray Gnatcatcher	Polioptila caerulea
Bluebirds, Thrushes and Robins	**Turdidae**
Eastern Bluebird	Sialia sialis
Swainson's Thrush	Catharus ustulatus
Hermit Thrush	Catharus guttatus
American Robin	Turdus migratorius
Thrashers	**Mimidae**
Gray Catbird	Dumetella carolinensis
Northern Mockingbird	Mimus polyglottos
Starling	**Sturnidae**
European Starling	Sturnus vulgaris
Waxwings	**Bombycillidae**
Cedar Waxwing	Bombycilla cedrorum
Silky-flycatcher	**Ptilogonatidae**
Phainopepla	Phainopepla nitens
Warblers	**Parulidae**
Orange-crowned Warbler	Vermivora celata
Virginia's Warbler	Vermivora virginiae
Lucy's Warbler	Vermivora luciae
Yellow Warbler	Dendroica petechia
Yellow-rumped Warbler	Dendroica coronata
Black-throated Gray Warbler	Dendroica nigrescens
Black-and-white Warbler	Mniotilta varia
American Redstart	Setophaga ruticilla
Prothonotary Warbler	Protonotaria citrea
Ovenbird	Seiurus auricapilla
Northern Waterthrush	Seiurus noveboracensis
Kentucky Warbler	Oporornis formosus
MacGillivray's Warbler	Oporornis tolmei
Common Yellowthroat	Geothlypis trichas
Hooded Warbler	Wilsonia citrina
Wilson's Warbler	Wilsonia pusilla
Yellow-breasted Chat	Icteria virens
Tanagers	**Thraupidae**
Summer Tanager	Piranga rubra
Western Tanager	Piranga ludoviciana

Common Name	Scientific Name
Towhees, Sparrows and Juncos	**Emberizidae**
Spotted Towhee	Pipilo maculatus
Chipping Sparrow	Spizella passerina
Lark Sparrow	Chondestes grammacus
White-crowned Sparrow	Zonotrichia leucophrys
Grosbeaks and Buntings	**Cardinalidae**
Rose-breasted Grosbeak	Pheucticus ludovicianus
Black-headed Grosbeak	Pheucticus melanocephalus
Blue Grosbeak	Passerina caerulea
Lazuli Bunting	Passerina amoena
Indigo Bunting	Passerina cyanea
Blackbirds, Meadowlarks and Orioles	**Icteridae**
Red-winged Blackbird	Agelaius phoeniceus
Eastern Meadowlark	Sturnella magna
Western Meadowlark	Sturnella neglecta
Yellow-headed Blackbird	Xanthocephalus xanthocephalus
Brewer's Blackbird	Euphagus cyanocephalus
Common Grackle	Quiscalus quiscula
Great-tailed Grackle	Quiscalus mexicanus
Brown-headed Cowbird	Molothrus ater
Bullock's Oriole	Icterus bullockii
Finches	**Fringillidae**
House Finch	Carpodacus mexicanus
Pine Siskin	Carduelis pinus
Lesser Goldfinch	Carduelis psaltria
American Goldfinch	Carduelis tristis
Evening Grosbeak	Coccothraustes vespertinus
Old World Sparrows	**Passeridae**
House Sparrow	Passer domesticus

Appendix 4

Relationships between brush management, fuel reduction, and river ecology in Texas and new Mexico: phase 1, task2 progress report

RELATIONSHIPS BETWEEN BRUSH MANAGEMENT, FUEL REDUCTION, AND RIVER ECOLOGY IN TEXAS AND NEW MEXICO: PHASE 1, TASK 2 PROGRESS REPORT

October 31, 2004

A JOINT VENTURE BETWEEN THE FOREST SERVICE AND THE TEXAS AGRICULTURAL EXPERIMENT STATION

Georgianne W. Moore and M. Keith Owens
gwmoore@ag.tamu.edu
m-owens@tamu.edu

Project overview

This study tests for potential water savings from vegetation removal efforts underway in the bosque ecosystem as part of a fire fuel reduction study on the Rio Grande River in New Mexico. Our work is part of a joint-venture with the USDA Forest Service Rocky Mountain Research Station. Our task is to determine whether the treatment strategies of removing invasive woody plants result in hydrologic benefits, which in turn may reduce fire risk by ameliorating drought conditions, and boost wildlife, especially those that depend on high flows and healthy native riparian vegetation.

Our primary objective is to compare transpiration in Rio Grande riparian cottonwood stands with and without invasive saltcedar understory for an entire growing season. The secondary objective is to assess patterns of water use and sapwood area within and among saltcedar trees/stands to develop predictive relationships based on tree size or stand structure. Our third objective is to use the predictive relationships to accurately scale water use measurements from a subset of trees to the stand level, and to develop simple inferential models based on vegetation characteristics that can be applied to stand management strategies.

Accomplishments

Study Area

In the first year of this project (FY03), a pilot study, funded by the Rio Grande Initiative, was conducted on the Pecos River and a study plan was developed based on our preliminary results. Beginning in early spring of 2004, six research sites (see table below) were selected that satisfied our research objectives while also providing opportunities to collaborate with key outside contributors. Five of the sites were in operation by early April 2004, with the sixth site delayed due to flooding until early May 2004.

In accordance with our primary objective, two pairs of sites with and without invasive saltcedar understory were selected. The first pair was located on Middle Rio Grande Conservancy District land just south of Albuquerque, NM. The untreated control stand (NCON) was located in the US Forest Service Fuels Reduction Study block North 1 (USFS-North1). The treated cottonwood-only stand (NTMT) was nearby in USFS-North3. A second pair of sites was located approximately 80 miles south of Albuquerque, NM at the Bosque del Apache National Wildlife Refuge. The treated cottonwood-only stand (STMT) was in USFS-South4. No FS untreated control stand was nearby, so a new site (SCON) was established that fit the control criteria. Long-term trends indicate that the riparian water table fluctuates more variably south of the confluence of the Rio Puerco, which poses a potential contrast in water availability between the northern and southern pair of sites.

Two additional sites (STOWR and PECOS) were selected that lacked a cottonwood overstory. These sites were dominated by monoculture stands of saltcedar. The purpose of these saltcedar-only sites was to contrast saltcedar water use in stands with and without cottonwood overstory. The secondary purpose was to forge partnerships with other scientists studying the hydrologic effects of saltcedar.

Site	River	Cottonwood	Saltcedar	R. Olive	Water Table	Ownership	Study Assoc.
SCON	Rio Grande	x	x		variable	BNWR	none
NCON	Rio Grande	x	x	x	stable	MRGCD	FS North 1
STMT	Rio Grande	x			variable	BNWR	FS South X
NTMT	Rio Grande	x			stable	MRGCD	FS North 3
STOWR	Rio Grande		x		variable	BNWR	UNM ET tower
PECOS	Pecos		x		stable	private	TCE restoration

We retained the site on the Pecos River in Loving County, Texas in collaboration with Texas Cooperative Extension. Dr. Charles Hart at TCE is conducting a very large scale restoration project (http://farwest.tamu.edu/rangemgt/prep.html) whereby 55 square kilometers of saltcedar have been treated. Our site there is located in an untreated control area near monitoring wells used to track water loss from the river. Compared to the Rio Grande, the Pecos River is saltier (Pillsbury 1981) has substantially lower flow, and only a narrow band of riparian vegetation separating the river from the Trans-Pecos desert beyond. The riparian water table is highly dependent on release of water from the Red Bluff Resevoir located just upstream.

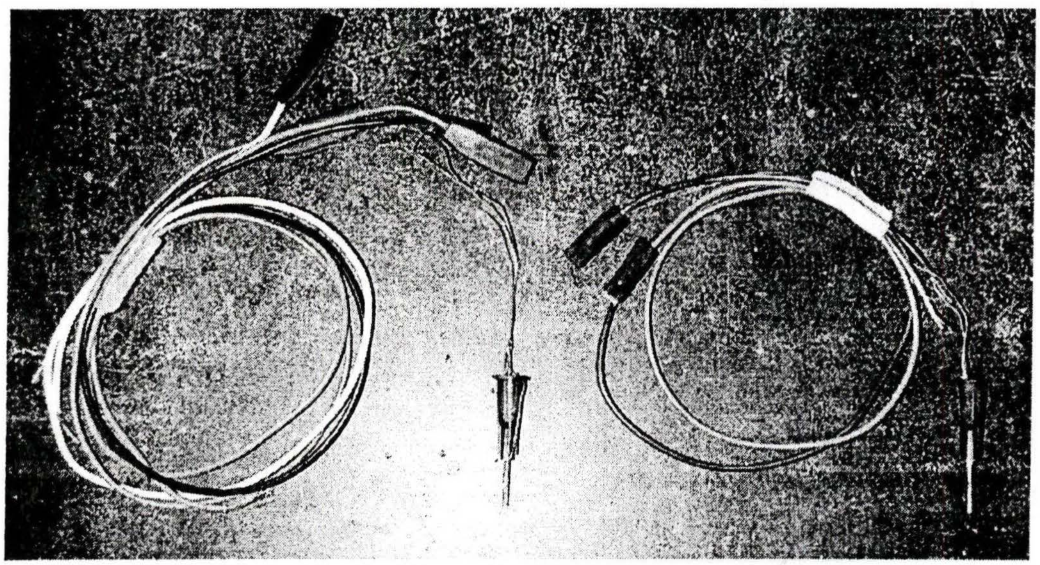
We formed a new partnership with the University of New Mexico. Drs. Cliff Dahm and James Cleverly at UNM have a tower at the Bosque del Apache National Wildlife Refuge to measure evapotranspiration (ET) from an expansive stand of saltcedar. Our site there is located beneath their ET tower (within the sampling area) so that we can compare our estimates of transpiration from individual stems to their stand-level estimates of ET.

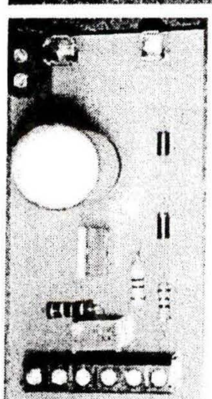
Another collaborative relationship was formed with Dr. David Merritt from the Rocky Mountain Research Station in Fort Collins, CO. He located gages to measure ET, based

on simple assumptions, in close proximity to three of our sites. Again, allowing for comparison of multiple approaches of estimating evapotranspiration.

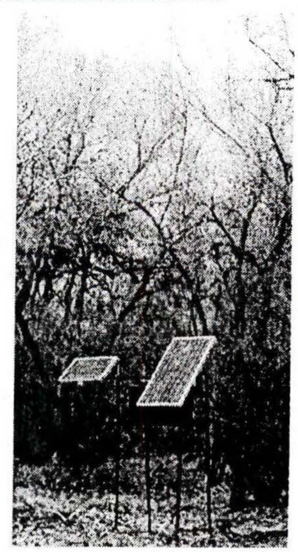
Instrumentation

Transpiration is measured using paired sap flow sensors (Granier 1987) that are assembled by hand (see photo below). The assembly process takes up to two hours per sensor pair. Although these sensors are commercially available, the cost savings of making them by hand enables us to greatly expand our sampling efforts. Over the course of this project, approximately 200 sensor pairs were constructed by hand from raw materials. Proper functioning requires extremely stable power supply in the field. Power supply regulators were also hand constructed from raw components, including 100 specially designed, custom made printed circuit boards (see photo below left). In addition, equipment was recycled from unrelated past research projects for use in this study.

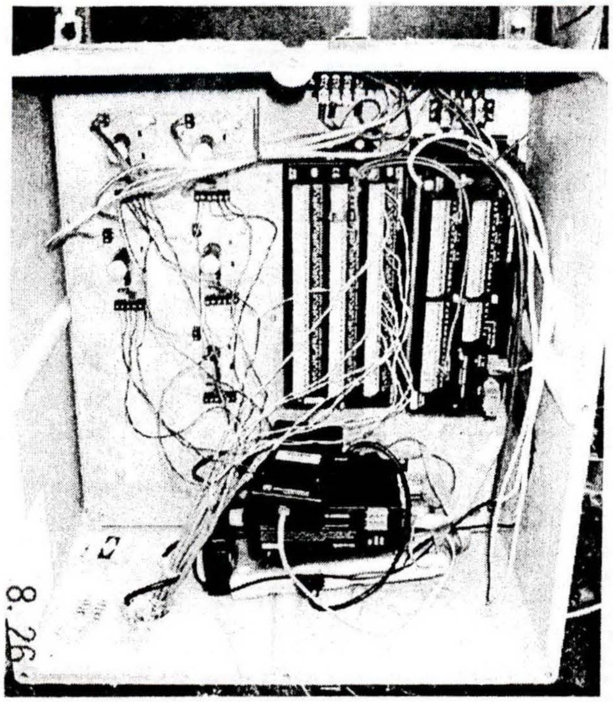




Each site was instrumented with at least nine sapflow sensors, depending on species composition. To power these, each site was equipped with at least four deep-cycle marine batteries that were charged by at least 100 watts of solar power (see photo right). To record data at 30-minute intervals, a datalogger (model CR10X, Campbell Scientific Inc.) and multiplexer (model 16/32, Campbell Scientific Inc.) was required (see photo next page). We also supplied each site with cellular phone capabilities so that data can be monitored and collected remotely



via modem. Unfortunately one of the six sites never established a cellular phone connection because of its remote location.

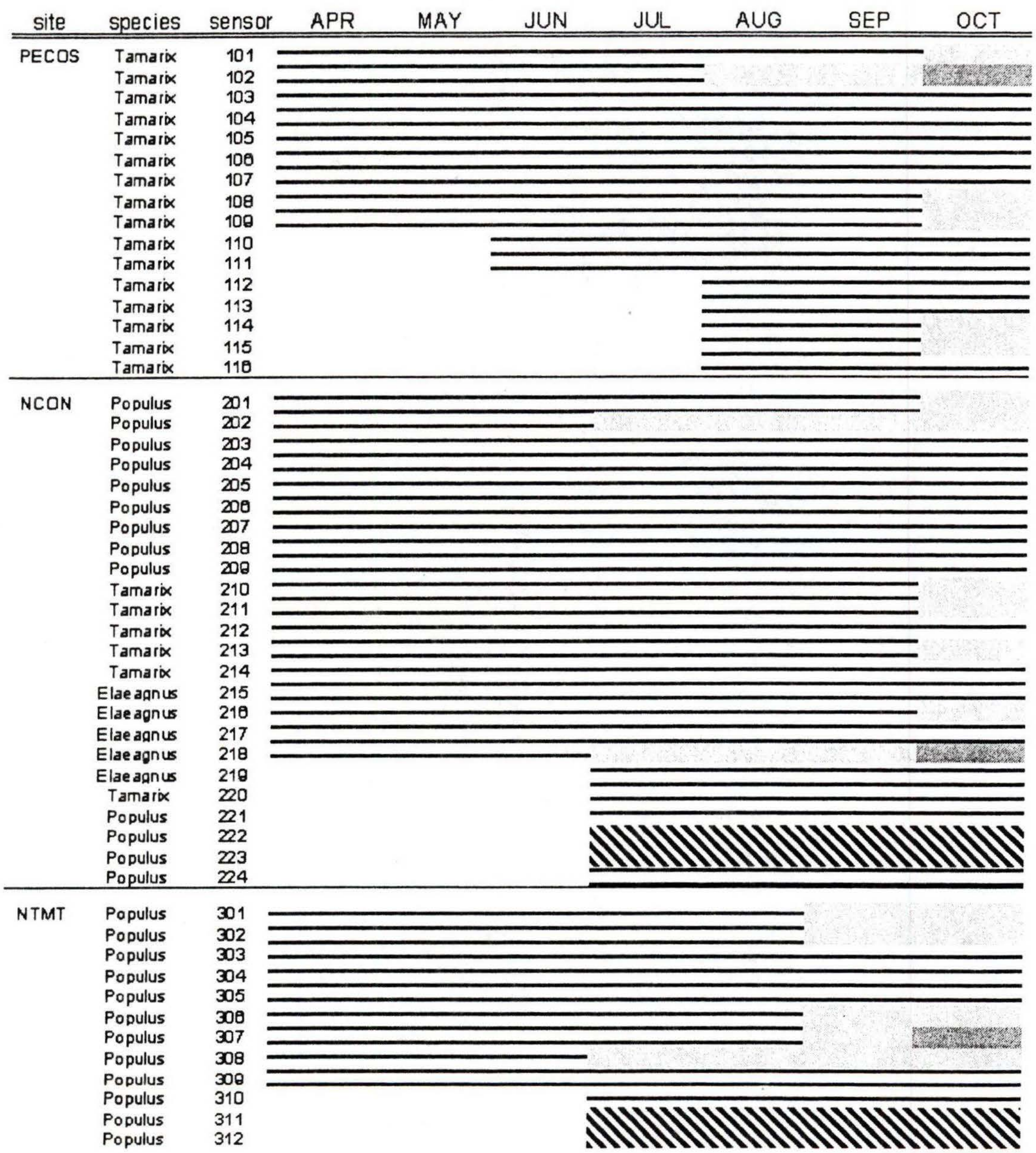


After the initial installation, sensors were frequently changed and/or added because of malfunction, uncertainty in longevity of the sensors as the trees grow throughout the summer, and as wounds develop around the insertion point. This method of sap flow measurement, although common in forests worldwide, had not been used in these species for long time periods prior to this study.

Because most cottonwood trees had sapwood that extended beyond the 1cm depth of the sensors, eight additional sensors (two per tree in four trees) were installed at depths of 1-2cm and 2-3cm in order to monitor radial variation in sap flux of cottonwoods.

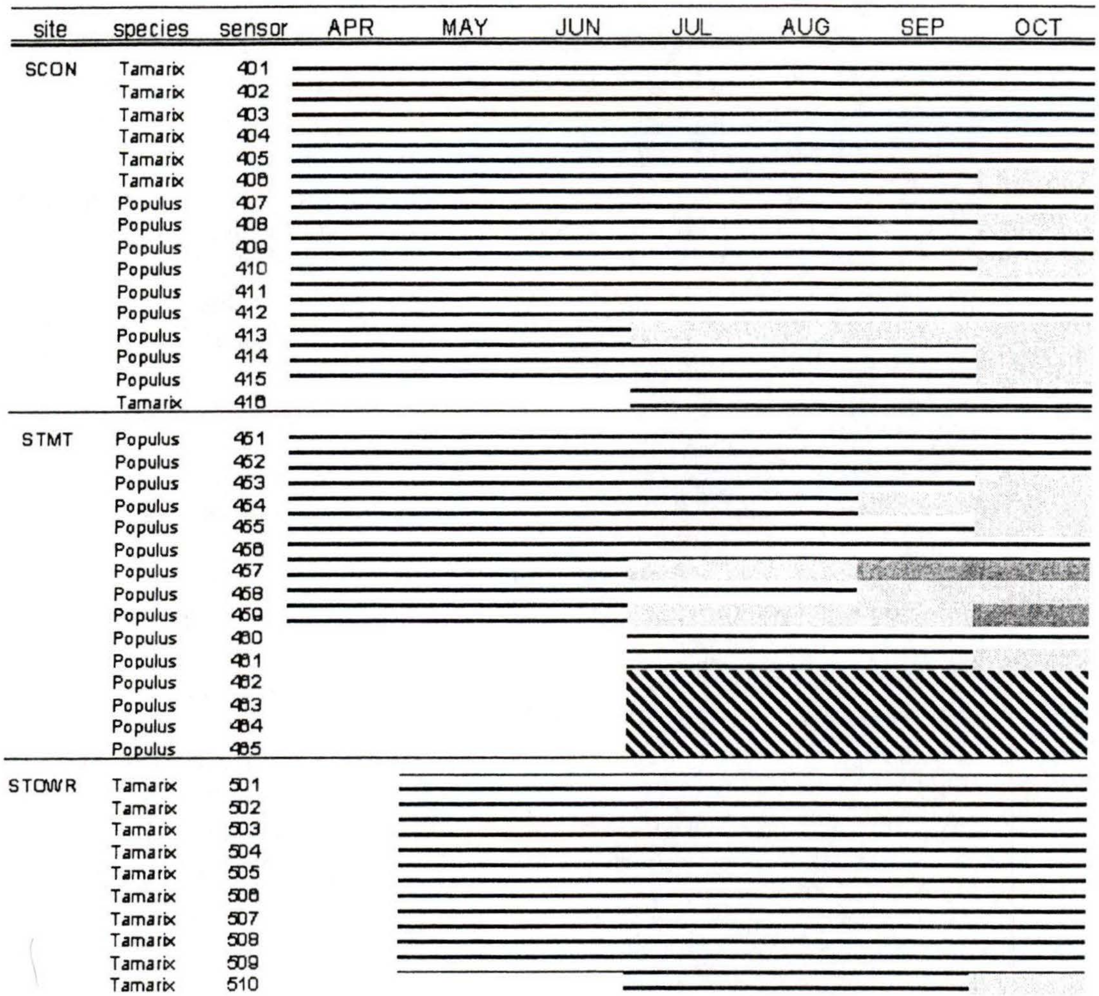
Installation began in early April (prior to leaf out) at all sites except STOWR. Installation at STOWR was delayed until early May because of flooding. By the end of the study period, a total of 93 sap flow sensors were in operation. A timeline outlining new installations (horizontal stripes) and re-installations (gray) by site is provided below. Deep sensors are identified by diagonal stripes.

Timeline of sapflow sensor installations by site.



Horizontal stripes – new installation
Gray – reinstallation (typically new location on same stem)
Dark gray – second reinstallation
Diagonal Stripes – installation in deep sapwood (1-2 cm or 2-3 cm)

Timeline of sapflow sensor installations by site (continued).



Horizontal stripes – new installation
Gray – reinstallation (typically new location on same stem)
Dark gray – second reinstallation
Diagonal Stripes – installation in deep sapwood (1-2 cm or 2-3 cm)

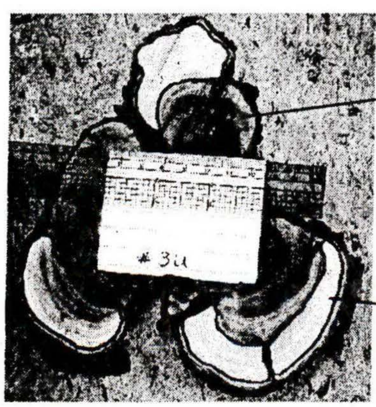
Progress toward goals

Developing protocols

The heat dissipation sap flow method (Granier 1987) was originally based on 2-cm length sensors. Sensors must be installed entirely into functional sapwood in order to properly dissipate heat into the conducting wood. Because of relatively shallow sapwood in the species studied, we utilized sensors that were 1 cm in length to minimize problems associated with partial installation into inactive heartwood. Thus the shorter sensors had different heating requirements that led to considerable adaptation of the power supply and regulation. Problems associated with improper power supply and regulation in early measurements caused substantial loss of data early in the season. Further loss of data due to partial installation into heartwood is expected once sapwood depth is destructively determined at the end of the measurement period.

Identifying sources of variation

The advantage of using sap flow techniques in individual trees to estimate stand transpiration is that it allows for the detection of tree-to-tree and species-to-species variation in water use. Because the unit of measurement is a point location in individual stems, a compromise is necessary between allocation of resources to sample within- vs. among-tree variation. Our task was to scale individual tree measurements to the stand, thus we chose to place one sensor per individual stem to best capture among-tree variation. In asymmetrical stems of saltcedar, as is common, placement was prioritized towards locations deemed actively growing, as judged by the appearance of young bark tissue near the apex of lobes. Thus we hoped to capture maximum potential sap flow rates in each stem, rather than attempt to sample average flow. This was necessary because of the likelihood of installation into inactive sapwood (see photo below). To partially compensate for bias toward maximum flow, stem selection represented a wide range of diameters and total leaf area.



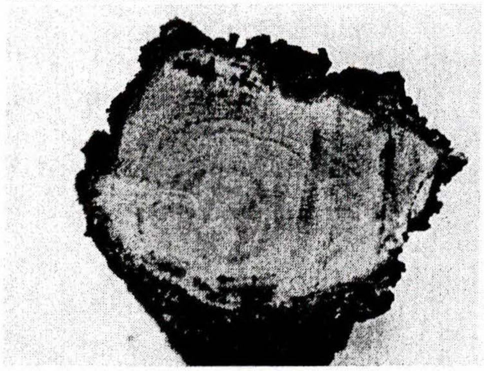
Dark, reddish heartwood does not conduct water

Water conducting tissue (i.e. "sapwood") is light colored

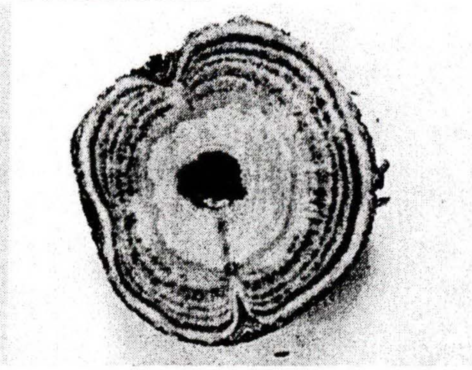
In saltcedar, most of the sap flow occurs in the outer 1-cm of the sapwood. This was verified using a dye injection in set of stems collected from the PECOS site. A solution of

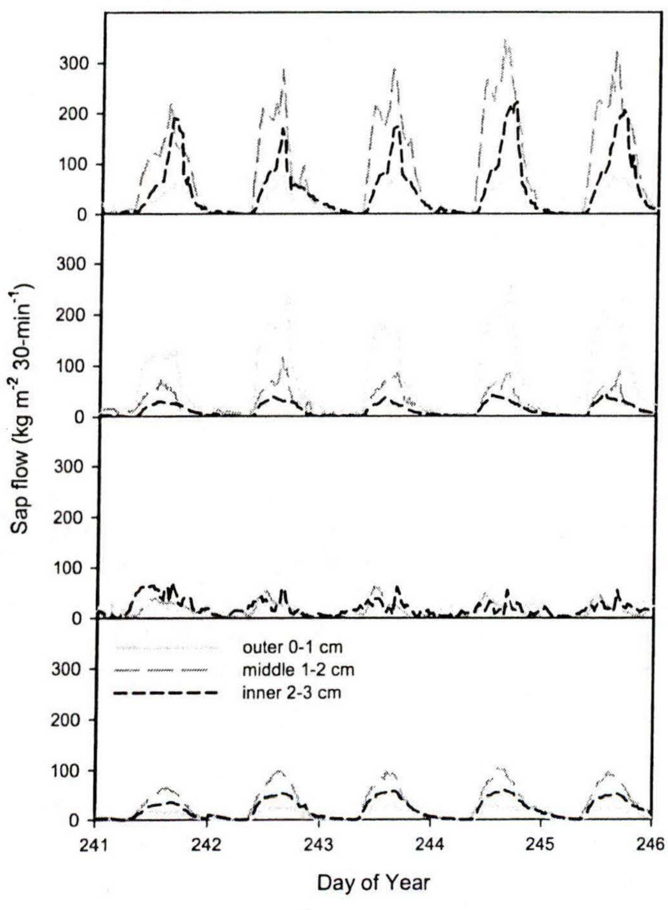
water and cresyl blue dye was gravity fed into cut stems. Actively conducting sapwood appears blue (see photographs below).

ASYMETRICAL



SYMETRICAL



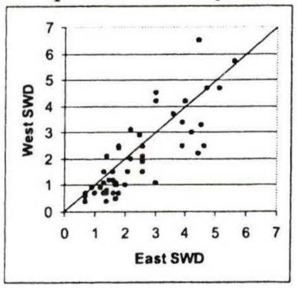


In contrast, the sapwood in cottonwood species extends beyond the 1-cm depth of our probes. Previous studies indicate that there is radial variation in the flow of water in *Populus* and many other tree species (Nadezhdina et al. 2002). To account for this variation, we equipped four cottonwood trees with sensors at 0-1, 1-2, and 2-3 cm depth. Sapwood depth of cottonwood averages approximately 3 cm (see section on *Cottonwood Sapwood Survey*). Results from a five day period are provided (see figure left).

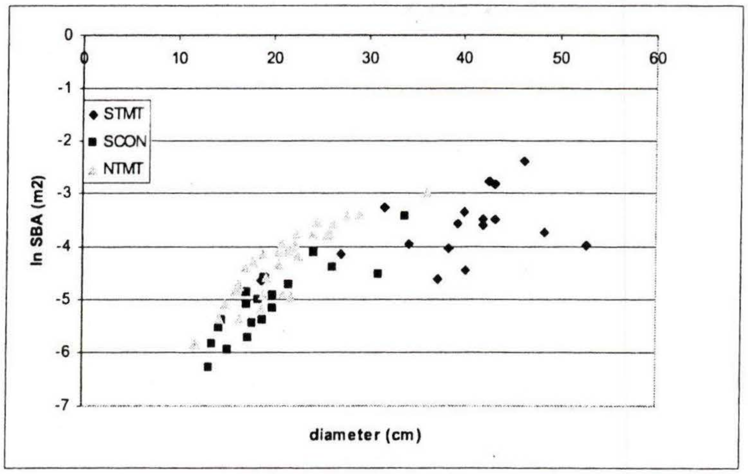
Flow in the outermost layer of sapwood was highest in only one of the four trees. In two cases, flow was the lowest in the outermost layer and highest in the middle 1-2 cm layer. The tree with the lowest flow rates exhibited little radial variation. Results from this small subset suggest that sap flow in cottonwood may be underestimated by sampling only the outer 0-1 cm of sapwood.

Cottonwood sapwood survey

Sapwood surveys in 30x30 meter plots at each site have been initiated, but are not yet completed. Surveys will be completed in late November 2004. Some preliminary results for cottonwood are provided herein. All cottonwoods in the 30 x 30 meter plots were cored on the east and west side at breast height (1.4 m) with a 5 mm increment borer. Sapwood depth was assessed visually according to wood color. There is no evidence of a difference in sapwood depth in the East and West directions (see figure left). Average sapwood depth of cottonwood at the STMT, SCON, and NTMT sites was 2.9±0.5, 1.4±0.2, and 3.0±0.2 cm, respectively.



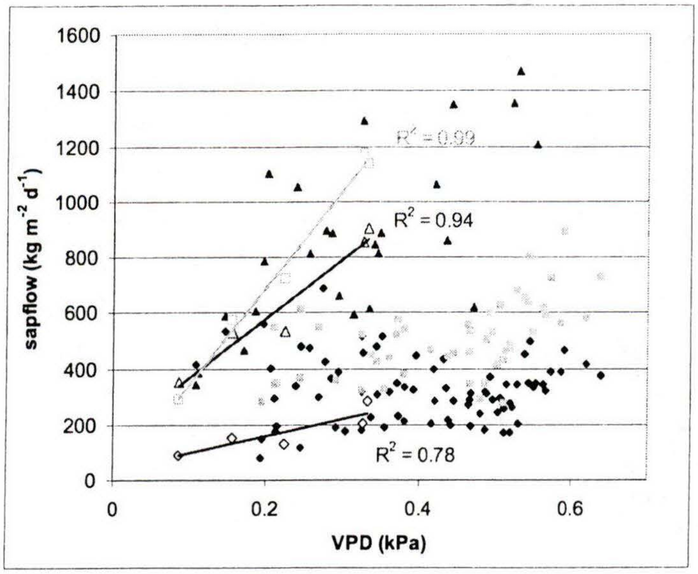
Tree size was a good predictor of sapwood area at these three sites (see figure right). Average diameters were larger at STMT compared to SCON or NTMT. Trees with the same diameter tended to have greater sapwood area at the NTMT site compared to the SCON site. When NCON data are available, we will assess whether this difference may be due to treatment or a difference in tree health between northern and southern sites.



Sensor longevity

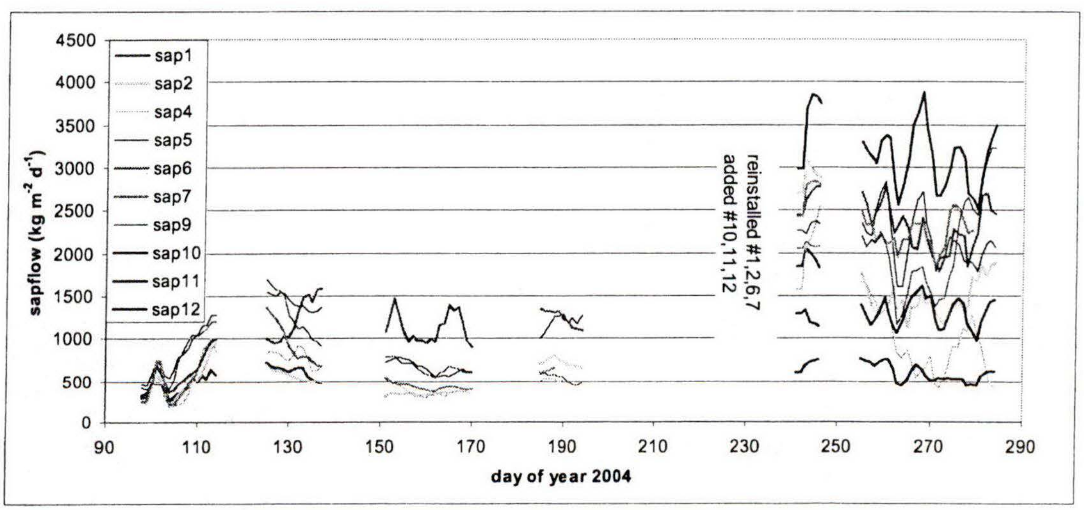
After a period of time, although sensors may still be functioning electronically, their ability to accurately represent flow rates in a tree may be impaired due to growth, wounding, or other changes in the flow path of water in the xylem. We periodically reinstalled sensors to test and account for such "temporal sampling errors" throughout the growing season. The potential for a problem with saltcedar, cottonwood, and Russian olive may be high due to their rapid growth rates and cottonwood's sensitivity to wounding.

Periodically, older sensors were retired and a new pair was installed in a new location on the same tree. Initial investigations suggest that temporal sampling errors are not apparent in either saltcedar or cottonwood (see figures below).



At the PECOS site, sensors were reinstalled in three saltcedar trees in mid-October after having been in place since April. The response to vapor pressure deficit (VPD) was used to standardize for climatic conditions (see figure left). The new sensors (open symbols) appear to respond similarly to VPD after reinstallation in two of the tree trees. Some within-tree variability is expected.

Because VPD data are not available at the cottonwood sites, temporal trends were examined for temporal sampling errors (see figure below). At the NTMT site, sensors were reinstalled in four cottonwood trees in late-August after having been in place since April (sensors 1, 2, 6, and 7); an additional three sensors were newly installed in trees that were not previously sampled (sensors 10, 11, and 12). Again, temporal sampling errors were not evident. After August (and a period of missing data) flow rates were higher in all sensors, including older ones (sensors 4, 5, and 9). All newly installed sensors were within the range of those that had been in place since April. Further investigation into possible temporal sampling errors will be carried out on the remainder of data from reinstalled sensors and any temporal biases accounted for in the final results.



Future directions

As of this report (October 31, 2004), measurements are still ongoing and are planned to continue until after leaf senescence. Sap flow rates are expected to decline to near zero before leaf abscission, which should occur by the end of November. Sites are scheduled for dismantling in early December, at which time sapwood surveys (discussed in the previous section) will be completed. In the 30 x 30 meter plots, all saltcedar or Russian olive stems will be severed at the base; cut stumps will be photographed and analyzed using Geographical Information Systems for the determination of sapwood area.

After the data collection phase is complete, efforts will focus on analyses and subsequent publications into peer reviewed journals. The principal topic for manuscripts will relate to our primary objective, which is to compare transpiration in Rio Grande riparian cottonwood stands with and without invasive saltcedar understory. Other manuscripts will arise from the collaborations with the Texas Cooperative Extension, University of New Mexico, and USFS Rocky Mountain Research Station in Fort Collins, Colorado.

Granier, A. 1987. Evaluation of transpiration in a Douglas-fir stand by means of sap flow measurements. Tree Physiology. 3:309-320.

Nadezhdina, N., J. Cermak and R. Cuelemans 2002. Radial patterns of sap flow in woody stems of dominant and understory species: scaling errors associated with positioning of sensors. Tree Physiology. 22:907-918.

Pillsbury, A.F. 1981. The salinity of rivers. Scientific American. 245:54-65.

Appendix 5

Response of riparian vegetation to mechanical removal of invasive plants, RMRS Middle Rio Grande Fuels Reduction Study (FRS): Progress to date

Response of riparian vegetation to mechanical removal of invasive plants, RMRS Middle Rio Grande Fuels Reduction Study (FRS): Progress to date

David M. Merritt, US Forest Service, Fort Collins, CO
and
Bradley Johnson, Colorado State University, Fort Collins, CO

September 15, 2004

Aims and Goals

Primary study objectives

This study was designed to complement the ongoing RMRS Middle Rio Grande Fuels Reduction Study through examining the effects of the mechanical removal of invasive plants on riparian plant communities along the Middle Rio Grande River. We sampled vascular plant species composition, soil texture and chemistry, canopy cover (available light) and composition, and litter characteristics at each of nine fuels reduction study sites along the Middle Rio Grande River in June-July, 2004. Using the existing controlled, randomized-block study design, our intent is to determine whether there is a significant response of vascular plant species to: 1) removal of exotic woody plants, mainly *Tamarix* and *Elaeagnus* and 2) removal of exotic woody plant species combined with replanting of sites with native woody species. As part of the sampling, we also recorded the occurrence of *Tamarix* and *Elaeagnus* re-sprouting along belt transects. Long-term proposed objectives of this study are to evaluate the efficacy of fuels reduction in: 1) restoring desirable characteristics of riparian plant communities along the Middle Rio Grande River and 2) to evaluate the effects of fuels reduction on age-specific *Populus* mortality, population structure, and individual fitness.

Secondary study objective

A secondary objective of our research along the Middle Rio Grande was to compare a calibrated atmometer technique of estimating potential evapotranspiration (ET) of sites to actual measurements of evapotranspiration (eddy covariance method) and transpiration (sap flow method). Our hypothesis is that atmometers overestimate actual ET, leading to inflated or erroneous conclusions about plant water use. The intent of this work is to quantitatively test this hypothesis and to quantify the degree to which calibrated atmometers overestimate (or underestimate) water use. We will also relate variations in water table elevation, plant physiological response to climatic conditions, and other site-specific factors to deviations of atmometer estimates from eddy covariance measurements.

This report is intended to describe progress to date rather than to present scientific findings of this study. Scientific findings will be presented once soil laboratory analyses are complete and data have been entered, compiled and analyzed.

Methods

Vegetation studies

We sampled species composition of vascular plants in each of three pre-established blocks. A total of nine sites were sampled in these three blocks, each of which contained two treatments (mechanical removal of woody exotics, mechanical removal of woody exotics and planting of native shrubs) and one control in each of the North, Middle and South blocks. The presence and percent cover of all vascular plant species were measured along belt transects placed perpendicular to the stream within each treatment block. Herbaceous and low woody species (less than 1 m high) were measured in continuous 4 m^2 plots placed continually along transects (Figure 1). Composition and cover of all overstory woody species (greater than 1 m high) were measured along transects using a densitometer and the line intercept technique. Soil samples (15 cm depth) were taken systematically at each end point and at 25 m intervals along the transects. Litter composition, percent coverage and depth were recorded along the entire length of each transect. Litter was classified as leaves, fine and coarse woody material, and wood chips (by-products of mechanical removal work). Cover of bare soil was also recorded.

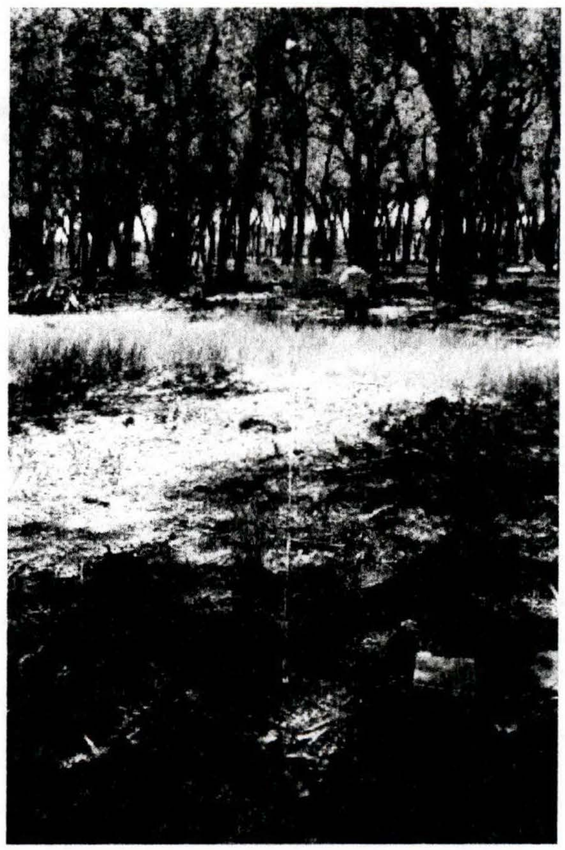


Figure 1. View of a typical vegetation transect; looking towards the Rio Grande.

Each of the belt transects was systematically established at each site. We first defined the boundaries of the study area (treated area or control). We then determined

the length of the site parallel to the river and established 50 m buffers at the upstream and downstream ends. We placed transects at even intervals along this length and established a permanent marker 10 m or more toward the river from the landward side of the boundary[1]. These transects were extended at a trajectory perpendicular to the river or along habitat patches to a distance 10 m landward from the riverside boundary of the treatment or a maximum distance of 100 m (Figure 2). Transects only included those stands dominated by *Populus* (defined as greater than 60% relative *Populus* cover) which at times necessitated variance from the idealized protocol described above.

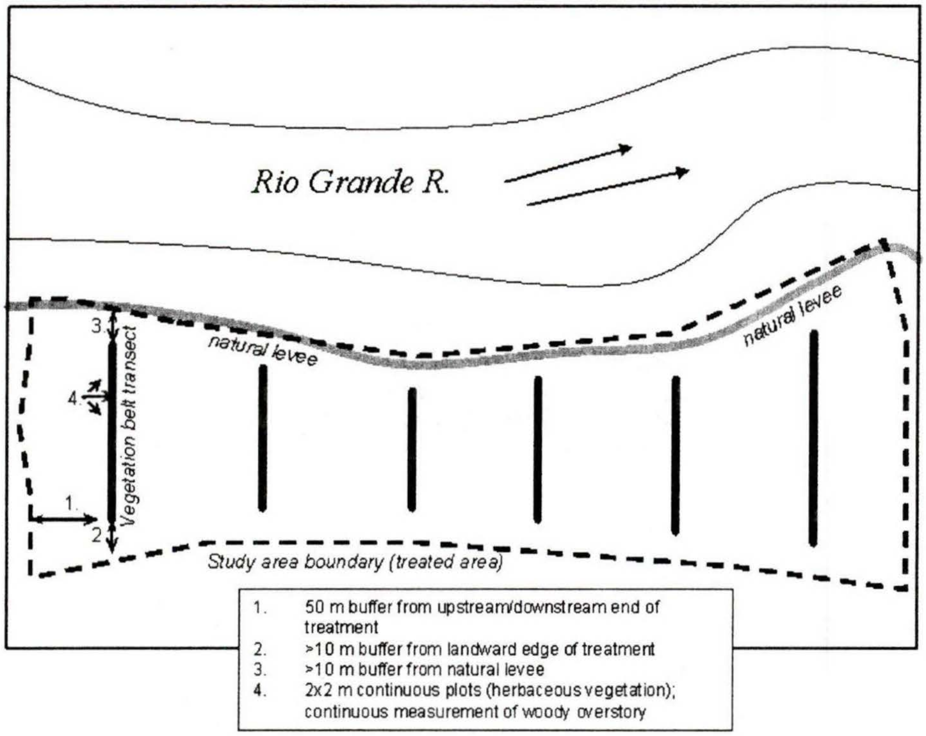


Figure 2. Layout of belt transects used for vegetation sampling.

Soil samples will be analyzed for major anions and cations, texture and percent organic material at the Colorado State University Soil and Plant testing Laboratory in Fort Collins, CO. Depth to groundwater has been measured at each site as a part of the fuels reduction study and will be incorporated into final data analyses. We did not re-dig groundwater wells, establish well logs, or collect samples to determine soil water content at the sites nor were plant tissue samples taken. The other components of the study were deemed sufficient for meeting the objectives of this work.

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[1] Rebar transect ends have all been marked with 3/8 inch rebar labeled with an aluminum tag. Labels include the letters "VEG" and the plot number. Pink pin flags (with "Wetland Delineation" printed on them) were placed along the transects between the end posts to facilitate relocation.

Potential evapotranspiration studies

ETGage™ atmometers are currently being widely used by agencies and the public to estimate "site specific ET" with the intent of estimating potential water salvage from removal of riparian vegetation. We will compare estimates of ET from these devices to more accurate measurements from sap flow and eddy covariance methods at the same sites. Deviations of the ETGage™ estimates from actual T and ET will be evaluated. Site temperature, relative humidity, and depth to water table will be used to help to explain deviations in estimated and actual ET.

ETGage™ calibrated atmometers fitted with Onset Hobo™ dataloggers were mounted at four locations along the Middle Rio Grande in July 2004. Each of the sites was also equipped with shaded Onset Relative Humidity and Temperature Sensors set to a measurement interval of each half hour (July-September 2004). Measurement sites at North 3 and South 4 were established adjacent to sap flow measurement sites. Sites were also established adjacent to eddy covariance towers (J. Cleverly, UNM) on Bosque del Apache National and Sevilleta National Wildlife Refuges. Data will be recovered and sites winterized in September, 2004. Evaporation data will be compared to eddy covariance and sap flow data and examined along with temperature, relative humidity, and groundwater data for each site.

Progress to Date and Preliminary Observations

A total of 47 transects were established at the nine study sites (Table 1). In total, species composition and cover were measured in 2,024 $4m^2$ plots and along more than four km of total transect length. Litter composition and coverage were also evaluated continuously along these transects and 277 soil samples were collected for chemical and textural analysis.

Table 1. Summary of vegetation sampling completed for the middle Rio Grande River Fuels Reduction Study.

Site	Treatment*	Site area sampled (ha)	Number of transects	Total transect length (m)	Number of $4m^2$ plots
North 1	Control	16	5	425	212
North 2	Mech-Rev	21	5	405	202
North 3	Mech	16	5	376	188
Middle 1	Mech	20	5	500	250
Middle 3	Mech-Rev	13	5	500	250
Middle 7	Control	35	5	466	233
South 1	Control	29	8	692	346
South 2	Mech-Rev	16	5	353	176
South 4	Mech	15	4	334	167
Total		181	47	4051	2024

*"Mech" is mechanical removal treatment and "Rev" is re-vegetation treatment.

General Observations

Herbaceous understory vegetation is generally sparse in the *Populus* bosques along the Rio Grande across all fuels reduction treatments and in the control sites. Understory vegetation cover measured in this study ranged from 0 to over 100%, but varied tremendously from plot to plot, with coverage typically being strongly patchy and dispersed. Overstory canopy cover and litter depth appear to exert a strong influence over cover and composition of understory vegetation. Cover and species richness appear to be lowest in the densest multi-layered canopy forests and in areas with thick organic litter (leaves, woody debris and wood chips). Not surprisingly, thick layers of wood chips were often very species poor, as plant colonization is inhibited in areas with thick leaf or woody debris cover (Figure 3). Even in canopy gaps, where we generally observed the highest species richness and cover, areas covered with wood chips from the mechanical removal of exotic woody species were sparsely vegetated.

Although the treated areas appeared to be more species poor than the control plots, species recovery in these areas will likely occur over the next several years. This first year of sampling in recently treated sites is more or less a "ground zero view". Much of the response to treatment will be realized in time.

Figure 3. View of thick wood chip layer at the Middle block. There are very few herbaceous species in these areas. Note re-sprouting *Elaeagnus* and *Tamarix*.

As was observed in Finch *et al.* 2002, there are measurable inter-site differences (even within a particular block) that are likely to explain some portion of the variability in vegetation between the sites. Soil moisture, depth to water table, and soil salinity are among these inter-site differences and these factors will be incorporated into our final analyses.

Soils are currently being analyzed. Soil chemistry, texture, and carbon content will be used, along with canopy cover data, litter composition, and depth to water table, to explain variation in plant community composition at the sites. After accounting for variation in species composition due to these abiotic and biotic factors, differences between treatments will be formally tested using variance partitioning in canonical correspondence analysis (Økland and Eilertsen1994). Furthermore, species richness and other composite attributes (life form, longevity, naturalness, etc.) of the plant communities will be formally compared between sites and treatments. These analyses will be aimed at testing specific hypotheses regarding differences in species composition between fuels reduction treatments.

The study design will also enable us to examine patterns such as the response of bosque vegetation to canopy cover and overstory composition. Because we have measurements of the spatial heterogeneity and composition of forest cover as well as the vertical structure of the forests along the Middle Rio Grande, we hope that these data may have application to other parts of the larger fuels reduction study, such as in characterizing habitat for organisms other than plants.

Plans for Future Work

During field site visits we made a number of observations that we developed into plans for future studies. At a couple of the sites, areas that we sampled were later burned by natural wild fires. We noted re-sprouts of certain species (eg., *Salix gooddingii, Apocynum canabinum, Tamarix ramosissima*) in as soon as two weeks after the fires in some cases. We would like to take advantage of these natural burns to sample mortality and canopy volume in these sites. We would compare sites that had been treated as part of the fuels reduction studies and those that had not been treated to compare the effects of fire on *Populus* mortality. These studies, would take advantage of natural wildfires, assist in understanding the efficacy of fuels reduction treatments, and provide us with a better understanding of patterns of *Populus* mortality in response to fires of a range of intensities.

Another area of interest to us is how the fitness of *Populus* is affected by the fuels reduction treatments. Incremental growth is one measure of fitness of individuals. We would propose to measure incremental growth of *Populus* sampled from each of the fuel reduction treatment sites and the controls. We would core a number of individuals at each treatment, relate past growth to environmental factors (temperature, precipitation, streamflow, and depth to groundwater). We would use this relationship to determine expected growth for post treatment years. We would hypothesize that incremental growth should be higher than would be predict from environmental factors in sites that have received fuels reduction treatment, but not in control sites. The strength of this portion of the study will increase with time (as we have more post treatment years to sample), but we should be able to detect an effect after as few as two years post-treatment.

These last two ideas could contribute to the fuels reduction study in that they have the potential to demonstrate whether the fuels reduction treatments are effective in both

decreasing *Populus* mortality from fire and in increasing *Populus* fitness. We would design the studies to detect such effects of fuels reduction if they exist.

Citations

Finch, D.M., J.M. Galloway, M.D. Means, and D.L. Hawksworth. 2002. Progress report for Middle Rio Grande fuels reduction study 2000-2002, Rocky Mountain Research Station-Albuquerque, New Mexico. Rocky Mountain Research Station, Albuquerque Report, NM.

Økland, R. H. and O. Eilertsen. 1994. Canonical correspondence analysis with variation partitioning: some comments and an application. Journal of Vegetation Science 5:117-126.